BULLETIN

OF

ENTOMOLOGICAL RESEARCH.

ISSUED BY THE IMPERIAL
BUREAU OF ENTOMOLOGY.

EDITOR: THE DIRECTOR.

VOL. XII.

LONDON:
THE IMPERIAL BUREAU OF ENTOMOLOGY,
41, QUEEN'S GATE, S.W.7.
1921–22.

IMPERIAL BUREAU OF ENTOMOLOGY.

Honorary Committee of Management.

Head Office.—British Museum (Natural History), Cromwell Road, London, S.W.7.

Publication Office.—41, Queen's Gate, London, S.W.7.

(6127) Wt.P6 200 1000 5/22 Harrow G.75.

CONTENTS.

ORIGINAL ARTICLES.

MISCELLANEOUS.

PLATES.

ERRATA.

Page 77, line 53, for "*vishuni*" read "*vishnui*"
,, 167, 10 lines from bottom, for "*Dipterocarpus*" read "*Dipterocarpus tuberculatus*"
,, 172, lines 22 and 24, for "*malabarica*" read "*malabaricum*"
,, 175, lines 10 and 12, for "*Eugenia jaman*" read "*Eugenia jambolana*"
,, 177, line 8, delete "Punjab"
,, 178, line 25, for "Punjab" read "United Provinces" and for "Rani Range" read "Rani Rau"
,, 285, line 28, for "Drouart" read "Drouard"
,, 350, column 3, line 28, for "*maurtitianus*" read "mauritianus"
,, 351, column 2, line 31, for "325" read "326"
,, 351, column 3, after "*tritaeniorhynchus*" add "turkhudi var. 280"
,, 351, column 3, line 24, for "325" read "326"
,, 351, column 3, last line for "*zammtitii*" read "*zammittii*"
,, 355, line 2, for "*vaporarorium*" read "*vaporariorum*"
,, 423, last line
,, 425, lines 1, 3, etc. } for "Johnson" read "Johnston"

IMPERIAL BUREAU OF ENTOMOLOGY.

BULLETIN

OF

ENTOMOLOGICAL RESEARCH.

VOL. XII. 1921.

A REVISION OF THE GENUS LEPTOCONOPS, SKUSE.

By HENRY F. CARTER,

School of Tropical Medicine, Liverpool.

INTRODUCTION.

The genus *Leptoconops* was erected in 1890 by the Australian dipterist Skuse for a minute black Chironomid fly which he captured at Woronora, near Sydney, New South Wales. This genus he placed in the last of the three sections into which he divided the family CHIRONOMIDAE, namely, the CERATOPOGONINA. The fly greatly resembled a small species of *Simulium* in general facies, and presented certain peculiar characters which rendered it strikingly distinct from other members of the section. Indeed, certain authors (Mik 1894, Johannsen 1905) have since drawn attention to the marked similarity in the wing venation of an American species (*L. torrens*, Twns.) and *Corynoneura*, a genus of the subfamily CHIRONOMINAE. Later (1907) Noé suggested the formation of an additional subfamily—LEPTOCONOPINAE—for the Australian and allied species (at that time classified in three genera), and Malloch (1915), although acknowledging that the genus *Tersesthes*, Twns. (a synonym of *Leptoconops*), was unknown to him, associated it with the CHIRONOMINAE rather than with the CERATOPOGONINAE. Apart from the wing venation, however, *Leptoconops* shows no affinities with *Corynoneura*, but rather agrees with the Ceratopogonine midges, particularly in regard to the structure of the thorax and mouth-parts. Several species of *Leptoconops* have now been described, but owing to differences in the interpretation of, or slight variations in, some of the generic characters given by Skuse, as well as to subsequent descriptive errors, they have, in greater part, been referred to the genera *Tersesthes*, Twns., and *Mycterotypus*, Noé. As was to be expected, however, the close agreement exhibited in the diagnoses of these genera and of *Leptoconops* has caused several authors to suggest their identity; but indefinite or partial conclusions* only were reached, since the genotype of *Leptoconops* (*L. stygius*, Sk.) was not re-examined.

Through the courtesy of several gentlemen (individual acknowledgments are made in the text of the systematic portion of this paper) I have been privileged

* Castellani and Chalmers (1913 and 1919) give *Tersesthes* and *Mycterotypus* as synonyms of *Leptoconops*, stating that in so doing they follow Kieffer. The latter author, however, did not definitely reject these names, and in his recent works still refers to them.

(416) Wt. P8/170 1,000 5/21 Harrow G75.

to examine the majority of the known species of this genus, including *L. stygius*, and have thus been able to decide certain questionable morphological characters which were largely responsible for the previous confusion. The new species described herein were received from the Imperial Bureau of Entomology (per Dr. G. A. K. Marshall), the British Museum (per Mr. F. W. Edwards), and the United States National Museum (per Prof. L. O. Howard and Dr. J. M. Aldrich); the types and co-types of these species have been returned to the collections from which they came, as subsequently indicated at the end of the respective descriptions.

Synonymy and Classification.

Skuse's definition of *Leptoconops* is as follows:—"Antennae in the female 2 + 11-jointed; first joint of scapus large, disciform; second smaller, globose; flagellar joints globose, gradually diminishing in size, more ovate towards the apex, terminal joint elongate-ovate. Proboscis prominent. Palpi four-jointed; first and second joints small, third greatly incrassated, about three times the length of the first or second; fourth not as long as the last, slender, cylindrical. Wings naked. All longitudinal veins taking their origin at the base of the wing. Marginal cross-vein present. Middle cross-vein wanting. Fourth and fifth longitudinal veins only forked."

In 1893 Townsend founded the genus *Tersesthes*, but although acquainted with Skuse's work, would seem not to have appreciated the close resemblance between his genus and *Leptoconops*. Practically the only points of difference between the two genera that can be obtained from his description are that the palpi are composed of three segments and the wings covered with microscopic hairs; but in his figure of the wing the costa is extended to the apex, terminating near the upper branch of the fourth vein.

Noé (1905) erected the genus *Mycterotypus* for two Italian midges. He was, however, doubtful as to its distinctiveness from *Leptoconops* and *Tersesthes*, and was unable to decide whether the differences between these two genera and *Mycterotypus* were real or apparent. But in view of the facts that he could distinguish satisfactorily only three palpal segments, that the venation apparently differed in several particulars, and chiefly that he believed the "cerci" (lamellae) to be absent in *Leptoconops*, he finally resolved to place his species in a separate genus.

Johannsen (1905) concluded that *Leptoconops* and *Tersesthes* were very closely related, if not identical, and that they could only be distinguished by the segmentation of the palpi. Kieffer (1906), however, retained all three of these genera, but subsequently (1908) suggested that they were probably synonymous and that Townsend's figure of the wing showing the extension of the costa to the apex was inaccurate. Langeron (1913), after studying the venation of a Tunisian species and the figures of the wings of *Leptoconops* and *Tersesthes*, considered the former genus and *Mycterotypus* very nearly allied, but expressed surprise that Kieffer should think *Tersesthes* and the latter identical. Lutz (1913) was the first author who actually compared specimens of any of these genera; he examined both of Noé's species of *Mycterotypus* and Townsend's *Tersesthes torrens*, and definitely decided that they were congeneric. De Meijere (1915) briefly discussed the differences which existed, or were said to exist, between the three genera, and concluded by adopting Kieffer's suggestion of identity and listing all the species then known under *Leptoconops*. The latter author, however, does not appear to have reached a definite decision in this regard, for although placing *Tersesthes* and *Mycterotypus* under *Leptoconops*, he yet (1917 and 1918) retains the names to indicate groups of species; moreover, in spite of previous suggestions of inaccuracy, he (1917) still accepts Townsend's interpretation of the wing venation, but employs it for purposes of specific differentiation!

Comparisons of the genotype species of *Leptoconops* (*L. stygius*), *Tersesthes* (*T. torrens*) and *Mycterotypus* (*M. bezzii*) have shown definitely that all are congeneric, and therefore the last two generic names must sink under *Leptoconops*. The value and nature of the various characters upon which the separation of these genera was based will be discussed later in connection with the external morphology.

In a supplement to his 1918 paper Kieffer divided *Leptoconops* into three genera as follows :—

" 1. Antennes de la ♀ composées de 12 articles ; crochets tarsaux simple, égaux, petits ; type : *kerteszi*, Kieff. (Région palearctique).
Genre *Holoconops*, n.g.

Antennes de la ♀ composées de 13 articles 2.

" 2. Crochets tarsaux de la ♀ bifides, les 2 rameaux inégaux (Indes orientales).
Genre *Schizoconops*, n.g.

Crochets tarsaux de la ♀ simple, inégaux au tarse antérieur, égaux au tarse postérieur (Australie). Genre *Leptoconops*, Skuse."

This classification cannot be maintained for two reasons : first, the two types of differential characters used are not of the same value and are neither of them sufficient for purposes of generic separation, and, secondly, the description of the claws of *Leptoconops* (with type *L. stygius*) is erroneous. *Holoconops* may be retained with advantage as a subgenus by reason of the antennal structure of the females, *Leptoconops*, in the restricted sense, being reserved for those species with the full complement of segments. *Leptoconops* (*sens. str.*) can, if necessary, be further separated into two groups on the structure of the claws ; but even if such groups be worthy of subgeneric rank, the name *Schizoconops* cannot be employed, since the genotype of *Mycterotypus* (*M. bezzii* was the first species described by Noé) possesses toothed claws, thus giving the latter name priority.

In 1915 de Meijere described a species (*L. albiventris*) from New Guinea which differed from all other *Leptoconops* in the structure of the ovipositor. The discovery of an African species possessing a similar ovipositor, and the fact that in both species this character is supported by others not present in *Leptoconops*, appear to justify the erection of a new genus ; this is described on p. 24 under the name *Acanthoconops*.

Distribution.

The members of the genus *Leptoconops* (*sens. lat.*) are widely distributed, but so far as is known are confined to countries lying approximately between the parallels of latitude 40° North and 35° South. Representatives occur in Italy, Sardinia, Asia Minor, Bengal, Siam, Northern, Central and South-West Africa, United States of America, Cuba, Brazil and Australia. The two species of *Acanthoconops* are found in New Guinea and Zanzibar.

Biology.

Nothing is known of the life-histories or early stages of these flies, and comparatively little concerning the habits of the adults. In fact, the only species which have been studied in any detail are *L. bezzii* and *L. irritans*, both of which were investigated by Noé (1905 and 1907) in the Roman Campagna ; and to a less extent *L. kerteszi* (*Mycterotypus laurae*), observations on which have been recorded by Weiss (1912) and Langeron (1913). Certain authors (Noé, Lutz, and, according to Weiss, Bezzi) have suggested, in view of the greatly developed ovipositor, that the eggs are not deposited superficially, and that the larvae are terrestrial, living among the roots of grasses, etc. Noé, indeed, excluded water as the larval habitat, since he failed to rear either of the Italian species from various aquatic larvae collected during his investigations, even although adults of both flies were present in enormous numbers at the time ; and because both species appeared and subsequently increased greatly in numbers at a period

when water was relatively scarce. Weiss, on the other hand, states that at Tabeditt, South Tunis, *L. kerteszi* and *Simulium maculatum*, Mg. (*S. lineatum*, Fries) occur in common swarms, and show such close association as adults that he believes the immature stages of the two flies will be found near together. In this connection I am indebted to Dr. J. M. Aldrich, of the United States National Museum, for the following interesting observation, which indicates that the larvae of *L. torrens*, at least, are terrestrial in habit. He writes: "Several years ago, before my connection with the Museum, I identified a few specimens as *Tersesthes torrens*. The two females, which I retained in my private collection, have labels reading, 'Maxwell, N.M. Reared from pupae of *Tachina mella*, Webster. No. 11154. C.K.Wildermuth.' The significance of the rearing record is that the adults made their appearance in a breeding cage containing pupae of the fly; this proves not parasitism, but that the larvae are terrestrial, as is known to be the case in some of the CERATOPOGONINAE."

A perusal of the data subsequently given in the systematic portion of this paper in connection with the habitats of the different species provides some indication of the types of country in which these flies are known to occur, and of the avidity with which they bite. It will be seen that they have been found in what appear to be both relatively dry and well-watered districts, also in low-lying as well as mountainous regions. Noé states that *L. irritans* is especially prevalent in the coastal plains of the Roman Campagna. Langeron records *L. kerteszi* from marshy places in the desert in southern Tunis; Willcocks (1918) has observed the same insect in the Nile delta; while Weiss, Townsend (1893) and others have found species at altitudes varying from 1,600 ft. to 7,000 ft. So far as is known, they are diurnal insects, continuing their activities throughout the hottest parts of the day. Noé states that in Italy *L. bezzii* and *L. irritans* (locally known as 'serapiche') appear towards the end of May, reach their maximum abundance about the middle of June, and then gradually decrease in numbers and disappear early in September. The females of several species are known to bite man and his domestic animals, and to the former at least sometimes cause great annoyance and inconvenience. In some districts they have gained an evil reputation, and indeed at certain seasons would appear to be very serious pests, since at the period of maximum abundance the females of some species attack in dense swarms. According to Noé, *L. irritans* may occur in such swarms that no defence is possible, and he adds that labourers working on the railway from Rome to Pisa were sometimes forced to take shelter in order to escape these massed attacks. *L. kerteszi* is also known to adopt this habit (Weiss), and Sambon (1913) states that Chalmers in the Nile delta "obtained from the fellahin a very definite history of small black, blood-sucking flies appearing in swarms, and Dr. Gough told him that this fly scourge of the delta is undoubtedly *Leptoconops*," Chalmers was unable to find *Simulium* in this region, but *L. kerteszi* is abundant in certain localities (Willcocks). Pratt (1907), writing on North American blood-sucking midges, says that Barber considers *Leptoconops* (*Tersesthes*) "much worse as a pest than any *Ceratopogon* (*sens. lat.*) he has ever encountered." The bites are painful and the subsequent local reactions irritating and persistent; *L. irritans*, in addition, also causes considerable discomfort by crawling about the body, among the hair, beneath the clothes, in the ears, etc. (Noé). Noé's observations, however, tend to indicate that in some respects the habits of different species are not identical; *L. bezzii* is said to prefer the neighbourhood of houses and outbuildings rather than the open plains, and to be particularly attracted by poultry, in the houses of which the females shelter overnight. Further, although the females apparently prefer blood for food, Noé has seen both sexes of this species on flowers, and remarks that the males are especially fond of *Euonymus*.

ASSOCIATION WITH DISEASE.

Grassi (1901) endeavoured to obtain the experimental infection of *L. irritans*, Noé, with malaria parasites. He fed twenty-eight "wild" females of this species upon

three patients, two of whom were infected with *Plasmodium falciparum* and one with *Plasmodium falciparum* and *Plasmodium vivax*. No infection of these midges occurred although females of *Anopheles maculipennis* fed at the same time and on the same patients became infected from two of the three cases. Grassi concluded that *Leptoconops* (*Centrotypus*) was not able to transmit human malaria.

In 1913 Sambon extended the possible carriers of pellagra to include, besides the SIMULIIDAE, certain blood-sucking midges; he particularly referred to *Leptoconops* in this connection, basing his chief reason for so doing on Chalmers's observations (see above) made in pellagra districts in Lower Egypt.

Chatton and Blanc (1917) in a paper on *Toxoplasma* and toxoplasmosis of the gundi (*Ctenodactylus gundi*) discuss the natural ectoparasites of this animal; among these they make specific mention of two biting flies, namely *L. kerteszi*, Kieff. (*Mycterotypus laurae*, Weiss), and *Simulium maculatum*, Mg. (*lineatum*, Fries).

SYSTEMATIC ACCOUNT.

Genus **Leptoconops**, Skuse (*sens. lat.*).

Leptoconops, Skuse, Proc. Linn. Soc. N.S.W. (2) iv, p. 288 (1890).

Tersesthes, Twns., Psyche, vi, p. 369 (1893).

Centrotypus, Grassi (*nomen nudum*), "Die Malaria: Studien eines Zoologen," Jena, p. 118 (1901).

Mycterotypus, Noé, Atti Accad. Lincei, Ser. 5, Rendiconti, xiv, p. 114 (1905); Arch. Zool. Napoli, iii, p. 101 (1907).

Mycteromyia, Lutz (*nec* Phil.), Mem. Inst. Osw. Cruz, iv, p. 24 (1912); ibid. v, p. 69 (1913).

Holoconops, Kieff., Ann. Mus. Nat. Hung., xvi, p. 135 (1918).

Schizoconops, Kieff., Ann. Mus. Nat. Hung., xvi, p. 135 (1918).

The external morphology of the adults of this genus has been discussed in detail by Townsend (1893), Noé (1905 and 1907), and Langeron (1913) in relation to the species described by them. Owing probably to lack of material, however, no general account based on the examination of a number of species has yet been given, and it is therefore thought advisable—especially in view of the discrepancies which have appeared—to include here a description of the more important structures.

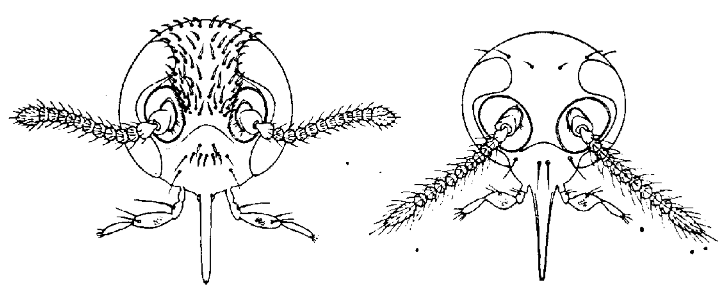


Fig. 1. Head of: (*a*) *Acanthoconops spinosifrons*, sp. n., ♀; (*b*) *Leptoconops kerteszi* var. *americanus*, n. (× 90 circa).

Head. Eyes bare, widely separate (the space between them varying from one-fifth to almost one-half the width of the head) in both sexes.* Vertex and occiput bearing a few short hairs or bristles; frons nude or with at most a single pair of short bristles between the eyes (fig. 1, *b*). Clypeus moderately pronounced, rounded, hairy.

Proboscis as long as, or rather less in length than, the height of the head. Mouth-parts in the female as follows: labium soft and hairy, broad, the labella relatively large; labrum strongly chitinised, broad at the base, gradually tapering towards a rounded apex, the extremity armed with three recurved teeth; hypopharynx less strongly chitinised than, but somewhat similar in shape to, the labrum, the apex devoid of teeth, pointed and scoop-like; mandibles and maxillae† well-developed, the former moderately chitinised, relatively broad and obliquely truncate or curved distally, bearing twelve to twenty-four small, closely apposed teeth, the maxillae narrower, slightly shorter and more pointed, armed with from twelve to thirty larger and more widely separated teeth. Mouth-parts in the male less strongly chitinised than those of the female; extremity of the labrum hairy, mandibles not visible (? absent) in the single specimen available, maxillae slender, thinly chitinised, pointed, without teeth.

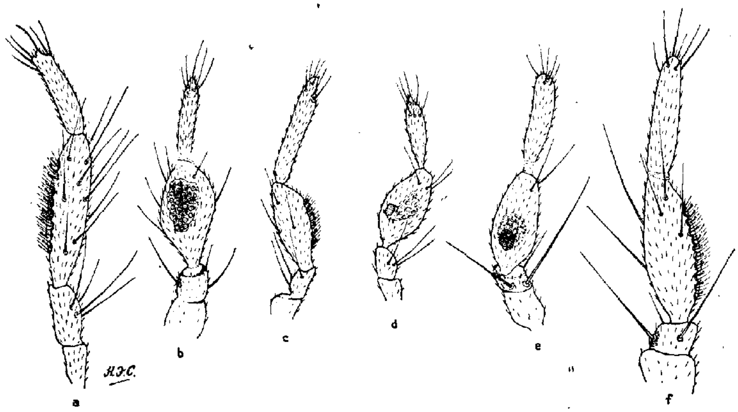


Fig. 2. Palpi of ♀♀ of: (*a*) *L. stygius*, Sk.; (*b*) *L. torrens*, Twns.; (*c*) *L. rhodesiensis*, sp. n.; (*d*) *L. kerteszi* var. *americanus*, n.; (*e*) *A. spinosifrons*, sp. n.; (*f*) *L. siamensis*, sp. n. (× 220 circa).

Palpi (fig. 2) composed of four segments. In the female the first and second segments are reduced in size and often indistinctly separated from one another, the third incrassate, the last relatively large, representing the combined small fourth and fifth segments of other CERATOPOGONINAE; the sensory pit of the third segment is highly developed, the orifice often large, occupying the greater portion of the inner aspect, or occasionally small, sub-circular; terminal segment with an apical whorl of hairs. In the male the palpi are longer than in the female, and the third segment is not, or scarcely, swollen.

* In this account remarks concerning male characters are based upon the examination of a specimen provisionally referred to *L. torrens* (see p. 15) and Noé's description of *L. bezzii*. The male of *L. kerteszi* (*M. laurae*, Weiss) is not considered here, since, as shown on p. 22, its structure in certain respects is so peculiar that confirmation of Weiss's observations is desirable before any definite statements can be made.

† Langeron (1913) in his description and figure of the mouth-parts of the female of *L. kerteszi* var. *peneti* (*M. laurae* var. *peneti*) has, through incorrect interpretation, transposed the names of these structures.

The confusion which has arisen in regard to the segmentation of the palpi has been entirely due to the somewhat rudimentary nature of the first and second segments, and to the varying degrees of differentiation exhibited by them in certain species. The palpi have thus been described as possessing four, three, or even two segments when the basal ones were overlooked or ignored.

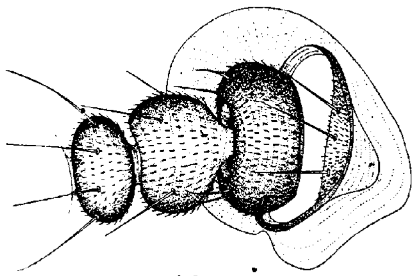


Fig. 3. Proximal portion of antenna of *Acanthoconops albiventris*, Meij., ♀, showing the reduced first segment; side view (× 510 circa).

Antennae set in large subcircular, pale-coloured, thinly chitinised, depressed areas. In the female the antennae (fig. 5, *a–h*, and *cf.* fig. 1) are pilose, composed of thirteen (subgen. *Holoconops*) or fourteen (*Leptoconops*, *sens. str.*) segments; first segment (*cf.* fig. 3) (ignored by all previous authors except Lutz) cup-like, broad at the apex, where there is a rim of thickened chitin, narrowing rapidly to a conical base; second segment large and rounded, the inter-segmental membrane connecting it to the chitinised rim of the first, extensive; segments of the flagellum eleven or twelve in number, all but the last with a distinct whorl of hairs and two or more transparent spines; third segment (first of the flagellum) relatively large, pyriform; terminal segment elongate-oval, considerably longer than any of the others; intermediate segments (4 to 12 or 13) almost uniform in shape and size, often transversely oval or subspherical, rarely narrowly oval. In the male the antennae are longer and plumose, composed of fifteen segments; the two basal segments similar to those of the female but larger, the second very large; segments of the flagellum as shown in fig. 4, *h*, and described on pp. 16 and 17.

Thorax arched anteriorly but not projecting over the head, with short and somewhat sparsely arranged hairs on the dorsal surface. Situated laterally, near the anterior margin, and centrally, in front of the scutellum, are small depressions somewhat similar to those found in *Culicoides*; in each anterior depression, however, are two or three separate oval or rounded, seemingly membranous, areas (which frequently appear as small shining black spots in dry specimens), not a single slit-like area as in *Culicoides*. Scutellum with the posterior margin gently rounded, slightly produced laterally, bearing two or three pairs of strong, and sometimes a few pairs of smaller, bristles. Post-scutellum strongly arched, nude.

Wings white, iridescent, with the surface entirely covered with minute upright setae and with a fringe of longer hairs on the distal and posterior margins. The venation (fig. 7) is characteristic, but the veins, particularly the anterior ones, are ill-defined and difficult to distinguish. They can best be followed in dry specimens, but careful manipulation is necessary, as the detection of certain details depends largely on the angle of view and the illumination; in mounted specimens (unless stained) the venation cannot be observed. The costa is short and, in the female, usually terminates

well before the middle of the wing. The sub-costa is chitinised and more clearly defined than any other vein ; it is closely apposed to the first longitudinal vein, and owing to the folding of the wing surface in this region, frequently obscures, or partly obscures, the base of the latter. The first and third longitudinal veins (the second is absent) are separate basally, but fuse distally, forming with the extremity of the costa a large, slightly raised, yellowish or pale brown area. These two veins are approximated throughout the greater portion of their course, but diverge slightly before fusing with one another and the costa ; this approximation is usually greatest immediately before the divergence mentioned above, and in several species is so close that amalgamation has taken place, with the results that an apparent cross-vein has been formed and a small cell isolated (*cf.* fig. 8, *a-l*). The anterior or radio-medial cross-vein is absent. The general course of the fourth, fifth and sixth veins shows little variation ; the upper branch of the fourth vein joins the apex of the wing below the middle, the lower branch is often very indistinct, with an apparently considerable portion of its base, and sometimes its apex, obsolete. At least three vein-like folds (indicated in fig. 7 by dotted lines) are present, and of these the most anterior—which is evidently homologous with the fold just above the upper branch of the fourth vein in other CERATOPOGONINAE—is relatively strong and conspicuous ; it is, indeed, as strongly marked as any of the veins except the sub-costa, and by most authors has been interpreted as the third longitudinal vein.

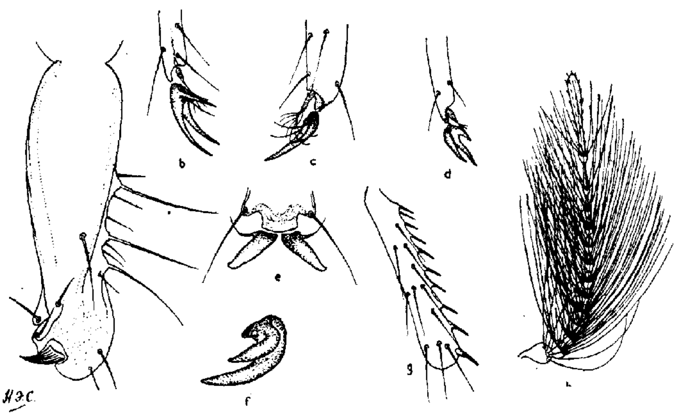


Fig. 4. *L.* (?) *torrens*, Twns., ♂ : *a*, clasper ; *b*, claws of front leg ; *h*, antenna (flagellum).
L. kerteszi var. *americanus*, n., : *c*, claws of hind leg (near claw foreshortened).
L. bezzii, Noé, ♀ : *d*, claws of middle leg.
L. stygius, Sk., ♀ : *e*, claws of front leg (ventral view empodium omitted).
L. siamensis, sp. n., ♀ : *f*, one claw of front leg.
L. brasiliensis, Lutz, ♀ : *g*, first tarsal segment of front leg.
(*a* × 770 ; *b*, *c*, *f* × 490 ; *d* × 220 ; *e* × 450 ; *g* × 260 ; *h* × 90.)

As will be gathered from a perusal of the subsequent specific descriptions and from the illustrations referred to above, this account of the wing venation is based upon the study of the wings of females of several species. Among these are included most of the forms previously referred to *Tersesthes* and *Mycterotypus*, and it therefore follows that the venation in these insects is in no way peculiar, and that venational characters which have been advanced for the retention or differentiation of these genera are either of little value or are the results of incorrect observations.

Legs moderately long, the hind pair longest, clothed with short hairs. Femora unarmed. Tibiae each armed distally with a short, stout, ventral spur, those of the fore and hind legs in addition with one or two oblique rows of bristles. First tarsal segment of the fore and middle legs about twice the length of the second, of the hind legs about one and one-half times the length of the second; second to fourth tarsal segments cylindrical, decreasing in length progressively, the fifth segment distinctly longer (in *L. lacteipennis* Kieffer states that it is shorter) than the fourth. Differentiation of the apical bristles of the first and second tarsal

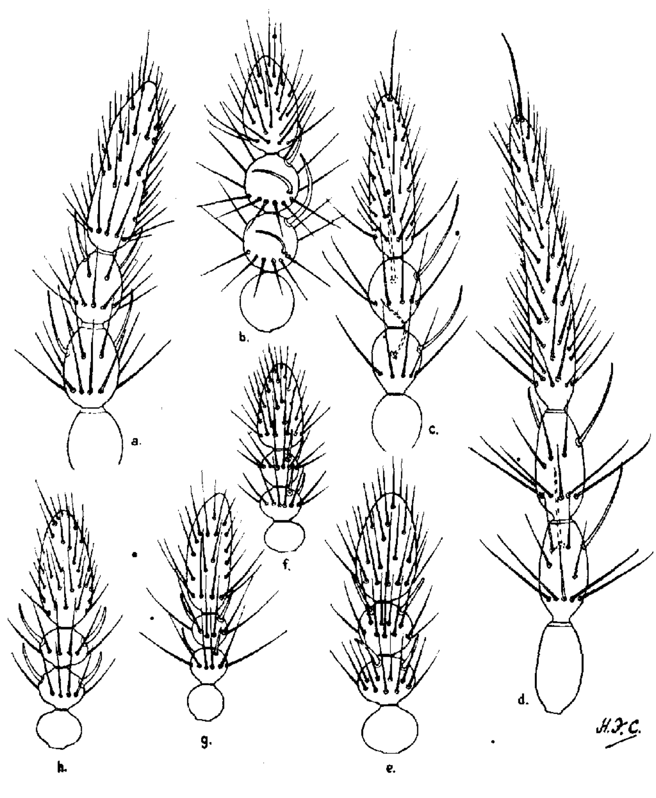


Fig. 5. Terminal segments of antennae of females of: (*a*) *L. siamensis*, sp. n.; (*b*) *L. stygius*, Sk.; (*c*) *L. grandis*, sp. n.; (*d*) *L. longicornis*, sp. n.; (*e*) *L. rhodesiensis*, sp. n.; (*f*) *Acanthoconops spinosifrons*, sp. n.; (*g*) *L. kerteszi* var. *americanus*, n.; (*h*) *L. torrens*, Twns. (× 260 circa).

segments into spines has taken place in most species, and of some of the ventral bristles of the first segment (fig. 4, *g*) in a few species. In the latter case considerable prominence has been given to this character by some writers in their specific descriptions, and the exact number and arrangement of such spines has been recorded; but variation in details is frequent, and may occur not only in

different individuals of the same species, but on different legs of the same individual (*cf.* footnote p. 20). Claws equal, small, less than one-half the length of the fifth segment; in the female similar on all the legs, either simple, each with a bristle arising from the base (fig. 4, *c* and *e*) or dentate, with a strong basal tooth (fig. 4, *d* and *f*); in the male (fig. 4, *b*) dissimilar on the fore and middle legs, one simple, the other with a long basal tooth (in *L. bezzii* both are said to be dentate), on the hind legs similar, simple. Empodium in the form of a minute branched bristle.

Abdomen of the female composed of nine segments—the ninth greatly reduced in size—clothed with short hairs, and bearing distally two exceedingly long, narrowly conical lamellae (fig. 6). Genital orifice, anteriorly, with a semi-circular chitinous border from which arise numerous small and a few long hairs, the latter directed inwards and backwards over the aperture. Spermathecae usually two in number (occasionally, e.g., *L. kerteszi*, a small third spermatheca is present), subspherical or oval and but slightly produced posteriorly before the junction with the duct. Abdomen of the male more slender than that of the female, the hypopygium conspicuous.

Subgenus **Leptoconops** (Skuse), Carter.

As here restricted, this subgenus includes only those species in which the antennae of the female are composed of fourteen segments; in this sex the species fall into two groups according to the claws being simple or dentate.

Leptoconops stygius, Skuse.

Leptoconops stygius, Skuse, Proc. Linn. Soc. New South Wales, (2) iv, p. 288 (1890).

Leptoconops skusii, Noé (error in explanation of Plate v), Arch. Zool. Napoli, iii (1907).

Skuse's description of this species, the type of the genus *Leptoconops*, is as follows:—

"♀.—Length of antennae, 0·42 mm.; expanse of wings, 1·27 mm.; size of body, 1·66 mm. Entirely black. Joints of antennae with dense light-greyish verticils. Head and thorax levigate, with minute black hairs. Abdomen about twice the length of the thorax, opaque, with some minute black hairs; lamellae very long, slender. Legs slender. Hind metatarsus one-third longer than the second tarsal joint. In the fore legs, the tibiae rather more than twice the length of the metatarsus. Wings hyaline, rather weakly iridescent; costal and first two longitudinal veins greyish-brownish, the rest pale and indistinct. Auxiliary vein not distinguishable, apparently wanting; first and second [*i.e.*, third] longitudinal veins reaching costa before the middle of the anterior border, confluent at the tips, tip of second longitudinal vein almost opposite but immediately beyond the tip of the posterior branch of the fifth longitudinal vein; marginal cross-vein indistinct; marginal cell small; third longitudinal vein [*i.e.*, the strong fold situated in the upper portion of the wing], arcuated, not quite reaching the margin, terminating a little above the apex of the wing; fourth longitudinal vein bellied downwards at the middle, reaching the margin a little below the apex of the wing, the posterior branch detached; fork of fifth longitudinal vein wide, the anterior branch twice the length of the posterior.

"*Habitat.* Woronora (Skuse). October."

Through the kindness of Professor S. J. Johnston, of Sydney University, I have been able to examine one of the three specimens of *L. stygius* contained in the Macleay Museum, Sydney, and am thus in a position to supplement the above description with some important morphological details.

♀.—Length of body (specimen mounted in balsam), 2·5 mm. ; length of wing, 1·3 mm. ; length of antenna, 0·48 mm. ; width of head, 0·40 mm.

Head. Eyes relatively narrowly separated, the space between them almost one-fifth the greatest width of the head ; clypeus with two pairs of short hairs. Third palpal segment (fig. 2, *a*) relatively not very strongly swollen, elongate, the orifice of the sensory pore extending over the greater portion of the inner side ; fourth segment subcylindrical, about two-thirds the length of the third. *Antennae* (fig. 5, *b*) : fourth to thirteenth segments spherical, with the hairs arranged in oblique whorls, and the spines unequal in size and asymmetrically arranged ; terminal segment short, approximately one and two-thirds as long as broad. *Wings* with anterior veins as shown in fig. 8, *a*.* *Legs :* first and second tarsal segments without differentiated spines, except distally. Claws (fig. 4, *e*) simple and equal, each with a bristle arising from the base. Lamellae bluntly rounded distally, 0·22 the length of the wing. Spermathecae two, heavily chitinised, subspherical (diameter 30μ) ; the commencement of the duct chitinised for a short distance.

Leptoconops longicornis, sp. nov.

♀.—Length of body (two specimens), 3·5 mm. ; length of wing, 2·2 mm. ; length of antennae, 0·84 mm. ; width of head, 0·44 mm.

Head black,† the antennal depressions pale brown, sparsely clothed with short hairs on the occiput and vertex ; clypeus blackish, with three pairs of dark brown hairs ; eyes not very widely separated, the space between them being approximately one-fifth the width of the head ; frons with a pair of short hairs situated, one on each side, near the lower margins of the eyes. Proboscis blackish brown. Palpi blackish brown, with dark hairs ; third segment elongate, relatively slightly swollen, the orifice of the sensory pit large, occupying the distal two-thirds of the inner side ; fourth segment subcylindrical, stout and short, not more than two-thirds the length of the third. *Antennae* (fig. 5, *d*) long, dark brown, bearing short brown hairs, and long, slightly curved, clear, pointed spines ; fourth to thirteenth segments subspherical to narrowly oval, from 1·0 to 2·1 as long as broad ; fourteenth segment approximately six and one-half times as long as broad, equal in length to the three preceding segments together. *Thorax* shining black (from indications still existing in the dried specimens the scutum was probably dark grey pollinose originally), sparsely clothed with short dark hairs ; scutellum normally with three pairs of stout black bristles ; pleurae and pectus shining black. *Wings* white, iridescent, the fusion of the extremities of the anterior veins forming an elongate brown spot near the middle of the upper margin ; anterior veins as shown (fig. 8, *b*), the distal interspace clearly defined, fifth vein bifurcating appreciably before the extremity of the costa. Halteres greyish buff, the stems somewhat infuscated. *Legs* uniformly dark brown, clothed with dark hairs ; tarsi without distinct spines (except perhaps a distal pair on the metatarsi), but with some of the ventral bristles on the first and second segments stout and spine-like. Claws, equal and simple, similar to those of *L. stygius*. *Abdomen* dark brown, with short dark hairs. Lamellae (fig. 6) paler brown, 0·18 the length of the wing. Spermathecae two, heavily chitinised, subspherical (diameter 50μ) ; the origin of the duct only chitinised.

---

* I have been totally unable to distinguish the small " vein " (termed by Skuse the " marginal cross-vein ") connecting the distal portions of the first and third veins. The first vein, however, bends sharply upwards just before its termination and at the angle is distinctly swollen, causing the lower edge of the vein to approach more closely that portion of the third vein immediately below it ; at first sight, therefore, the first and third veins appear to be connected at this point and to enclose a minute distal interspace.

† The colours given in the descriptions of this and the following species are as observed in specimens which had been dried after preservation in formalin.

Habitat. Interior of Western Australia: (*J. W. Dakin*), 1915. Five females (two cotypes) in the British Museum Collection.

Professor Dakin states that these midges do not trouble one before 10 a.m., and that they disappear at dusk; in between these hours they bite furiously, and the bite irritates for days afterwards.

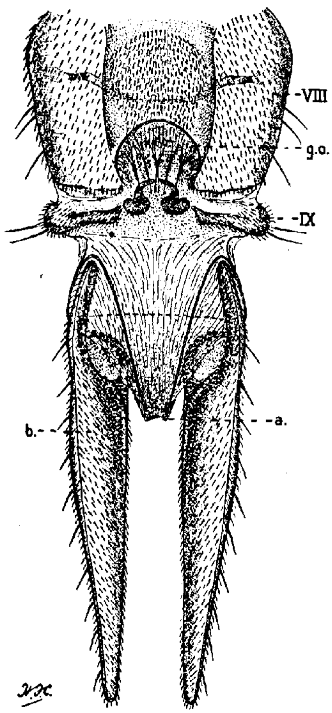


Fig. 6. *Leptoconops longicornis*, sp. n., ventral view of extremity of abdomen of ♀; *g.o.*, genital orifice; viii, sternite of eighth segment; ix, sternite of ninth segment; *a*, anus; *b*, lamellae; (× 180 circa).

Leptoconops grandis, sp. nov.

♀.—Length of body (one specimen), 3·5 mm.; length of wing, 2·0 mm.; length of antennae, 0·62 mm.; width of head, 0·44 mm.

Two females of this species, captured at the same place and time and bearing the same data attached to the label as the specimens of *L. longicornis*, were included in the material collected by Professor Dakin. Indeed the two forms were contained in the same tube and, except in antennal structure and certain details of minor importance, resemble one another so closely that, in the absence of males, it is difficult

to know exactly what value to place upon the differences observed. The antennal structure, however, differs so strikingly that I believe specific separation to be warranted; especially since no tendency to intermediate characters occurred in the small series of specimens obtained, and no obvious variation has been seen in the antennal structure of species of which numerous examples have been examined.

The antennae (fig. 5, *c*) are very distinctly shorter than in the preceding species, and the intermediate segments of the flagellum (4 to 13) are subspherical, being from 1·0 to 1·1 times as long as broad; the terminal segment is almost three and one-half times as long as broad, and is equal in length to the preceding two and one-half segments together. Minor differences appear to exist in regard to the venation (*cf.* fig. 8, *b* and *c*), and the dark grey pollinosity of the head and thorax; but, as indicated above, the appearance of the latter may be that normally found in *L. longicornis.*

The two females (cotypes) of this species are in the British Museum Collection.

The three Australian representatives of *Leptoconops* (*L. stygius, L. longicornis* and *L. grandis*) at present known are closely related, and as a group are characterised by the relatively narrow space separating the eyes, the structure of the palpi (*i.e.* in regard to the relative lengths of the third and fourth segments), and the absence of spines on the first and second tarsal segments.

Leptoconops braziliensis, Lutz.

Tersesthes braziliensis, Lutz, Mem. Inst. Oswaldo Cruz, v, p. 66 (1913).

The description of this species given below is drawn up from that published by Dr. Lutz, and from microscopical preparations kindly lent me by him.

♀.—Length of body (two specimens), 1·5 mm.; length of wing, 0·8 mm.; length of antennae, 0·32 mm.; width of head, 0·23 mm.

Head dark brown; clypeus with a few short, dark hairs. Proboscis and palpi dark brown; the latter with the third segment moderately swollen and the orifice of the sensory pit large and oval, the fourth segment subcylindrical, almost equal in length to the third. *Antennae* dark brown, with dark hairs and short, slightly curved, clear spines; fourth to thirteenth segments transversely oval, from 0·6 to 0·8 as long as broad; thirteenth segment somewhat pointed distally, two and one-half times as long as broad, almost equal in length to the preceding four segments together. *Thorax* dark brown, clothed with short hairs; pleurae and pectus rather paler in colour than the dorsum. *Wings* white, the basal part of the costa waxen yellow-brown, the costa extending to the middle of the anterior border; anterior veins arranged as in fig. 8, *g*, the fifth vein bifurcating before the extremities of the third vein and costa. Halteres with pale knobs and brown stems. *Legs* brown, the tarsi paler; metatarsi of the four anterior legs (fig. 4, *g*) with several pairs of distinct spines, of the hind legs with short stout bristles, but with spines only at the apex (distal pair); second tarsal segments of all the legs with a pair of spines at the apex. Claws simple and equal, each with a bristle arising from the base. *Abdomen* dark brown dorsally, the fore and hind margins of the tergites narrowly paler; venter pale brown. Lamellae waxen brown, darker at the extreme base, relatively long, 0·33 the length of the wing. Spermathecae two, strongly chitinised, oval ($33\mu \times 24\mu$).

Habitat. Brazil: lower reaches of the Rio Tocantin.

According to Lutz this species sucks blood and often attacks man. It may be readily distinguished from other species of *Leptoconops* (*sens. str.*) which possess simple claws by the unusually long lamellae.

Leptoconops irritans, Noé.

Mycterotypus irritans, Noé, Atti R. Accad. Lincei, Ser. 5, Rendiconti xiv, p. 118 (1905); Arch. Zool. Napoli, iii p. 138 (1907).

Centrotypus irritans, Grassi (*nomen nudum*), "Die Malaria: Studien eines Zoologen," Jena, pp. 118-122 (1901).

This species occurs with *L. bezzii* (see page 17) in the Roman Campagna, where, according to Noé, it is very abundant from June to the end of July, and may be found in diminished numbers late in August. The female only is known, and in this sex the species may readily be distinguished from *L. bezzii* by its general facies. Noé confined himself to a comparative description, and gave the following principal differences between it and the latter species.

Size smaller (length, 1·5 mm.; spread of wings, 2 mm.); proboscis and palpi relatively longer, the former more slender, cylindrical; antennal hairs sparser and more spinose; claws simple, the large basal tooth replaced by a robust bristle; abdomen white, becoming isabella-coloured dorsally.

To these I am able to add further details of specific importance, obtained from Sardinian specimens sent me by Professor M. Bezzi.

♀.—Length of body (one specimen), 1·7 mm.; length of wing, 1·1 mm.; length of antenna, 0·53 mm.; width of head, 0·30 mm.

Eyes separated by about one-third the width of the head. Antennal segments 4 to 12 transversely oval to spherical, the length from 0·7 to 1·0 the width; terminal segment about two and one-third times as long as wide, slightly longer than the two preceding segments together. Scutellum with two pairs of bristles. Metatarsi of the fore and middle legs with a few small but distinct spines ventrally, of the hind legs with short, stout bristles, intermixed with which may be one or two spines. Lamellae approximately one-fifth the length of the wing. Spermathecae two (in the single preparation examined a third, very small, oval spermatheca was also present), highly chitinised, oval, relatively large ($64\mu \times 36\mu$), the commencement of the duct chitinised for a very short distance.

Noé's figure of the female palpi shows an exceptionally long, slender terminal segment. This segment, if the drawing is accurate, is considerably longer than the third (the ratio being 1·2 : 1)—a condition which does not occur in any other species. Unfortunately in the specimens at my disposal the palpi are absent or so damaged or arranged that details cannot be observed.

Habitat. Italy: Roman Campagna; Sardinia, Cagliari. According to Weiss, Bezzi believes that both *L. irritans* and *L. bezzii* are widely distributed in Northern Italy.

Leptoconops rhodesiensis, sp. nov.

♀.—Length of body, 2·5 mm.; length of wing, 1·2 mm.; length of antenna, 0·4 mm.; width of head, 0·33 mm.

Head shining black, clothed with short, blackish hairs on the vertex and occiput; clypeus dark brown, with several (about twelve) dark-coloured hairs; eyes rather widely separated, the space between them about one-third the greatest width of the head. Proboscis dark brown or black. Palpi (fig. 2, *c*) dark brown, with dark hairs; third and fourth segments elongate, the third much swollen, with the orifice of the sensory pit moderately large, subcircular, and almost centrally situated, the fourth slightly longer than the third. *Antennae* (fig. 5, *e*) dark brown, with short paler brown hairs and relatively stout blunt spines; segments 4 to 13 transversely oval to subspherical, the length being from 0·6 to 0·9 times the breadth; fourteenth segment ovate, as long as the two preceding segments together. *Thorax* shining black, clothed

with short black hairs ; scutellum and postscutellum similarly coloured, the scutellum with three pairs of black bristles ; pleurae and pectus shining black. *Wings* (fig. 7) whitish, strongly iridescent ; first and third veins joining the anterior margin near the proximal third, point of bifurcation of the fifth vein situated considerably beyond the extremities of the costa and third veins. Halteres whitish, opalescent. *Legs* : femora and tibiae dark brown, with pale hairs, metatarsi and second tarsal segments without conspicuous spines, except distally, where differentiation (into spines or stout

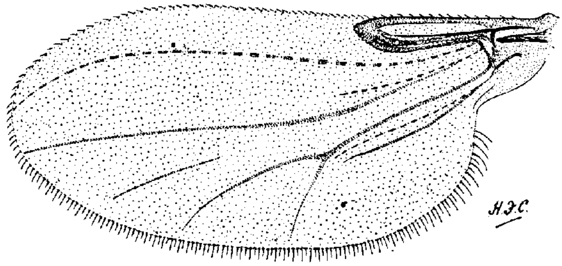


Fig. 7. Wing of *Leptoconops rhodesiensis*, sp. n., ♀ (× 75 circa).

spine-like bristles) of the apical pair of bristles often takes place. Claws equal, simple, each with a short bristle arising from the base. *Abdomen* : dorsum sepia-coloured (shining when held in certain positions), the apical margins of the tergites narrowly paler brown ; venter sepia-coloured medially, paler brown laterally ; both surfaces with short dark hairs. Lamellae dusky white or light grey, 0·2 times as long as the wing. Spermathecae strongly chitinised, apparently elongate-oval (collapsed in the single specimen available) ; the commencement of the duct chitinised for a very short distance.

Habitat. North-Western Rhodesia : Kafue Flats, 3,000 ft., 19.x.1913 (*R. C. Wood*), " Biting myself " ; 1 ♀ (type) in the collection of the Imperial Bureau of Entomology.

This species should be recognised without difficulty by the wing venation, the hort extent of the anterior veins being a conspicuous character. From *L.* (*Holoconops*) *nterruptus*, End., the only other species yet described from South Africa, it may, of ourse, be immediately separated by the structure of the antennae. The coloration f the abdomen given above must be regarded with reserve, since the specimen was aught when biting and probably contained undigested blood.

eptoconops torrens, Twns.

Tersesthes torrens, Twns., Psyche, vi, pp. 369-371 (1893).

This species, the type of the genus *Tersesthes*, Twns., belongs to the group of species n which the claws are simple. I am indebted to Professor L. O. Howard and r. J. M. Aldrich for the opportunity of examining female specimens from the Organ ountains, New Mexico, and a microscopical preparation of a male from Las Vegas ot Springs, New Mexico. The females were collected by Townsend on horses, and gree in all essentials with his description ; the males, however, cannot at present be ore than provisionally associated with this species, but in view of Weiss's descrip-on of the male antennae of *L.* (*Holoconops*) *kerteszi* (*M. laurae*, Weiss), appear

to be referable to it rather than to the other American species—*L. kerteszi* var. *americanus*, nov.

♀.—Length of body (one specimen), 2·2 mm. ;* length of wing, 1·1 mm. ; length of antennae, 0·33 mm. ; width of head, 0·30 mm.

Head shining dark brown or blackish, the antennal depressions cinnamon-coloured, clothed with short dark hairs on the vertex and occiput ; clypeus dark brown, with twelve hairs—five on each side and two central ; eyes separated by a space equal to about one-third the width of the head. Proboscis black. Palpi (fig. 2, *b*) blackish brown ; third segment greatly swollen, with the orifice of the sensory pit large, more or less ovate, occupying the distal two-thirds of the inner side ; fourth segment sub-cylindrical, distinctly (one-fifth) shorter than the third. Antennae (fig. 5, *h*) short, dark brown, with greyish hairs and moderately long, curved spines ; fourth to thirteenth segments transversely oval, from 0·6 to 0·8 as long as broad ; fourteenth segment slightly more than twice as long as wide, equal in length to the three preceding segments together. *Thorax* shining black or blackish brown, sparsely clothed with short dark hairs ; scutellum with three pairs of black bristles, the central pair large. *Wings* whitish, the anterior veins terminating in a brown stigma at some distance before the middle, arranged as in fig. 8, *e* ; fifth vein bifurcating below the ends of the costal and third veins. Halteres white, the stems infuscated. *Legs* blackish brown, the tarsi paler brown ; metatarsi and second tarsal segments without spines except at the extremities. Claws simple, equal, each with a basal bristle. *Abdomen* brown, distinctly paler than the head and thorax, with short dark hairs. Lamellae brown, 0·18 the length of the wing. Spermathecae two, highly chitinised, sub-spherical (diameter 36μ) ; the commencement of the duct scarcely chitinised.

♂.—Length of body (one specimen), 1·9 mm. ; length of wing, 1·1 mm. ; length of antennae, 0·71 mm. ; width of head, 0·30 mm.

General coloration apparently (so far as can be judged from a balsam preparation) dark brown or blackish, the tarsi paler. *Head* : frons bare, occiput and vertex with scanty hairs ; clypeus with two pairs of short hairs, eyes widely separated, the space between them being two-fifths the width of the head. Palpi : third and fourth segments sub-equal, the third slender, the sensory organ situated in the distal half. *Antennae* (fig. 4, *h*), very similar to those of the male *L. bezzii* (*q.v.*), but with the basal segments of the flagellum less compressed, the fourteenth segment relatively shorter (about three and one-half times as long as wide, and slightly more than one-third the length of the last segment), and the fifteenth segment more strongly swollen distally ; fourth to thirteenth segments varying from 0·6 to twice the width, fifteenth segment nearly eight times as long as the greatest width (*i.e.*, near the distal extremity), fourteenth and fifteenth segments, taken together, about equal in length to the preceding seven segments united. *Thorax* : scutellum with two pairs of bristles.† *Legs* slender, especially the middle and hind pairs ; metatarsi of the four anterior legs with a few small spines (usually one pair at the base and apex and one, unpaired, near the middle), hind metatarsi and second tarsal segments with a pair of spines or spine-like bristles at the apex. Claws of the fore and middle legs equal, one with a long basal tooth (fig. 4, *b*), the other with a bristle ; of the hind legs equal and simple. *Hypopygium* : Unfortunately the single preparation available is not in a sufficiently good condition to allow a satisfactory interpretation of the detailed structure of the intermediate appendages, but the claspers (fig. 4, *a*) are of peculiar form and will probably provide specific characters.

* Townsend gives the length of the body (including the lamellae) as 1·6 mm. to 2·2 mm. according as the abdomen is empty or distended with blood.

† The characters afforded by the wings cannot be determined in microscopical preparations with any degree of accuracy, unless the specimen is stained. In addition, the wings in the specimen described were considerably twisted.

Habitat. U.S.A. — New Mexico: Continental Divide, 7,000 ft., 21st June, *C. H. T. Townsend*—type series), Organ Mountains, 5,700 ft., 29th Aug. (*C. H. T. ownsend*—♀♀ described above); Las Vegas Hot Springs (*H. S. Barber*— ♂ described bove).

Dr. Aldrich informs me that, besides the localities mentioned above, the *Leptoconops* naterial in the United States National Museum includes females from Arizona, olorado, Florida, Texas, Utah and Cuba, and males from Arizona. The specimens rom Utah are *L. kerteszi* var. *americanus*, nov., but the others have not yet been efinitely determined, and are provisionally referred to *L. torrens*.

Pratt (1907) mentions several of the foregoing localities, including Utah, in onnection with *L. torrens*.

eptoconops bezzii, Noé.

Mycterotypus bezzii, Noé, Atti R. Accad. Lincei, Ser. 5, Rendiconti xiv, p. 114 (1905); Arch. Zool. Napoli, iii, p. 137 (1907).

Leptoconops hyalinipennis, Kieff., Ann. Mus. Nat. Hung. xvi, p. 33 (1918).

The following description of *L. bezzii* (♀) is drawn up from specimens collected in entral Italy and sent me by Professor M. Bezzi; to this gentleman I am also idebted for the loan of microscopical preparations of the palpi and antennae of he type male.

♀.—Length of body (two specimens), 2·1 mm.; length of wing, 1·2 mm.; length f antenna, 0·56; width of head, 0·45 mm.

Head black, clothed on the vertex and occiput with short dark hairs; clypeus lack or blackish brown, with two pairs of short dark hairs; eyes moderately widely eparated, the space between them about one-quarter the width of the head; frons ith a pair of short hairs near the lower margins of the eyes. Proboscis dark brown, alpi dark brown, with dark hairs; third segment strongly incrassate, the orifice of the ensory pit very large, narrowly oval, extending almost the entire length of the inner ide; fourth segment subcylindrical, slightly shorter than the third. *Antennae* ark brown, with short dark hairs and clear spines, which are somewhat strongly urved on the distal segments; fourth to thirteenth segments transversely oval to ubspherical, the length from 0·8 to 1·0 the breadth; fourteenth segment about wo and one-quarter times as long as broad, equal in length to the preceding wo and one-third segments together. *Thorax* black, sparsely clothed with ort black hairs; scutellum black, with three pairs of dark bristles (one of the all lateral bristles sometimes wanting); postscutellum, pleurae and pectus black. *ngs* white, iridescent, the anterior veins arranged as in fig. 8, *f*; fifth vein bifurcating ghtly beyond the end of the costa. Halteres white. *Legs* dark brown or brownish ck, the metatarsus and second tarsal segment paler, yellowish brown, each with a r of apical spines. Claws (fig. 4, *d*) equal, each with a stout basal tooth. *Abdomen* k brown, clothed with short black hairs. Lamellae yellowish brown, 0·2 the gth of the wing. Spermathecae two, heavily chitinised, oval (70μ by 54μ); the nmencement of the duct only chitinised.

The male obtained and associated with this species by Noé differed from the nale chiefly in regard to the palpi, antennae, claws and wings. The antenna isists of fifteen segments, the third (*i.e.* the first segment of the flagellum) being oduced basally into a relatively long stalk, and causing the flagellum to be more tinctly separated from the basal segments than in the female; the fourth to rteenth segments become progressively longer and narrower, the most proximal ment being very short and broad (0·4 to 0·7 the length), with chitinous thickenings the distal margins, the thirteenth subspherical basally but produced anteriorly

(the greatest width being 1·8 the length); the fourteenth and fifteenth segments greatly elongate, the former about half the length of the latter, and when united almost equal in length to the remaining segments of the flagellum taken together. The palpi are longer and more slender than in the female, the third segment elongate, scarcely swollen, with the proximal two-thirds of the inner side excavated, the fourth segment somewhat swollen distally, approximately four-fifths the length of the third. The wings are more delicate, and (from Noé's figure, not his interpretation) the first and third veins appear to be fused basally, and to enclose a large interspace distally; the separate distal portion of the first vein is very short and directed abruptly upwards towards the costa, the separate portion of the third vein long, extending at first almost parallel with the costa, then curving gradually upwards to meet it a short distance beyond the middle of the anterior border and above the bifurcation of the fifth vein. The claws, according to Noé, are dissimilar, those on the anterior legs being provided with a long basal tooth, those on the hind legs simple, with a short basal bristle.

Kieffer's description of *L. hyalinipennis* agrees so closely with Noé's description of *L. bezzii*, and with the specimens at my disposal, that I have no hesitation in placing it as a synonym of the latter species.

Habitat. *L. bezzii* is now known to occur in the Roman Campagna, Central Italy, and (as *L. hyalinipennis*) in Tunis (Djebel Djeloud; Korbons; Aouina, Lac Bahira; Tunis, Parc Belvedere).

Leptoconops flaviventris, Kieff.

Leptoconops flaviventris, Kieff., Ann. Mus. Nat. Hung. xvi, pp. 34 and 85 (1918).

Kieffer's description of the female of this species is as follows :—

"♀.—Semblable à *L. hyalinipennis*, sauf les caractères suivants: Bouche plus longue que la hauteur de la tête, dirigée en arrière. Palpes de 3 articles, dont le 1er est mince et un peu plus long que gros, seulement un article après laflexion, comme chez *hyalinipennis*. Antennes à articles 3-12* très transversaux, soies sensorielles plus courtes que les poils des verticilles, 13e en ovoide allongé, sans verticille, au moins aussi long que les précédents réunis. Mesonotum luisant. Ailes blanches, nervures très pâles. Tarses blanchâtres, articulations sombres. Abdomen jaune soufre. L. 1·3 mm.

Djebel Tunisie. Djeloud (5♀)."

On a later page Kieffer recorded additional specimens, including a male from Asia Minor—"Kyaldja-Su, viii (Naday), 1 ♂; Emirley; Sulejman, H. Yayla; Karapunat, 7 ♀ (Naday)." The male, which he doubtfully associated with this species, is shining black, with brown legs and a pale brown abdomen, but from the description given it is difficult to select any very definite characters by means of which it may be distinguished from the male of *L. bezzii*. Kieffer, however, states that the proboscis is very long and slender—much longer than the height of the head—and that the metatarsi are devoid of spines. Segments four to thirteen of the antenna appear to be similar in form to those of the Italian species, but the distal portions of these organs were evidently damaged, and Kieffer was unable to determine whether fourteen or fifteen segments were present. The claws are merely described as long (more than half the length of the fifth tarsal segment), but apparently the association with *L. flaviventris* would imply that on some of the legs, at least, they are also toothed.

* In this and subsequent direct quotations the number of the antennal segment given by the author cited must, for correctness and uniformity, be increased by one; but in all the descriptive extracts given this change has already been made.

Of the species of *Leptoconops* occurring in the Mediterranean littoral *L. flaviventris* pparently most closely resembles *L. irritans* in general facies. In both species the odomen is normally pale in colour—whitish or yellowish—but they should be easily parated by the structure of the claws.

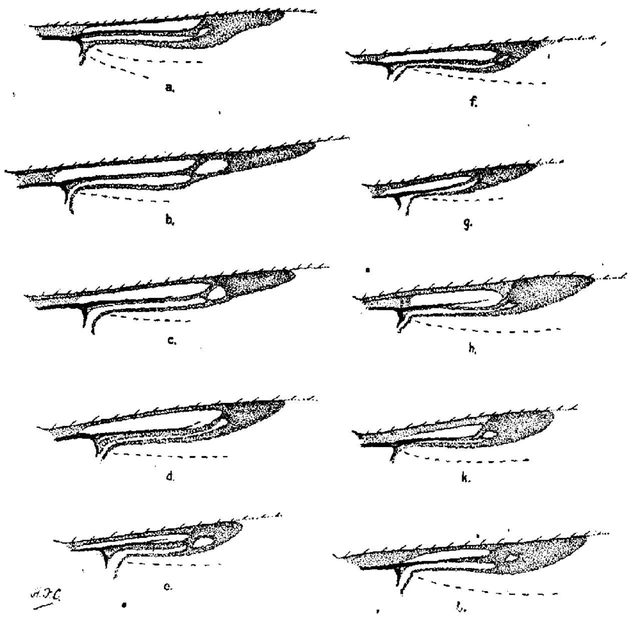


Fig. 8. Basal portions of wings of females of: (*a*) *L. stygius*, Sk.; (*b*) *L. longicornis*, sp. n.;) *L. grandis*, sp. n.; (*d*) *L. siamensis*, sp. n.; (*e*) *L. torrens*, Twns.; (*f*) *L. bezzii*, Noé; (*g*) *brazilinesis*, Lutz; (*h*) *L. kerteszi*, Kieff.; (*k*) *L. kerteszi* var. *americanus*, n.; (*l*) *A. spinosifrons*, n. (*b*, *c*, *d*, × 50 circa; the rest × 75).

ptoconops indicus, Kieff.

Schizoconops indicus, Kieff., Ann. Mus. Nat. Hung. xvi, p. 135 (1918).

This species was made the type of the genus *Schizoconops* by Kieffer on account of toothed or bifid ungues. This character alone, however, cannot be considered of fficient importance to warrant the creation of a new genus; and even were it of ogeneric value the name *Schizoconops* would sink under *Mycterotypus* (see p. 3).

The chief characters, taken from Kieffer's description, are as follows :—

♀.—Shining black. *Antennae* brown, the fourth to the thirteenth segments nsverse, at least twice as broad as long; fourteenth segment conical, equal in gth to the four preceding segments together. *Wings* white, with pale veins; t and third veins not reaching the middle of the anterior border, fifth vein ırcating much beyond the extremity of the third vein. Halteres white. *Legs* pale

416)

brown, tarsi whitish, metatarsi without spines ; anterior femora slightly thickened ; claws bifid, equal, the branch shorter. *Abdomen* red ; lamellae long and whitish.

Length 1·5 mm.

Habitat. Bengal : Champaran, Bettiah, iii, 1908.

This species should be easily recognised by the structure of the claws, the absence of spines on the metatarsi, and the relative positions of the extremity of the third vein and bifurcation of the fifth vein ; that the latter should take place considerably beyond (" très distale ") the junction of the third vein with the costa is unusual.

Leptoconops siamensis, sp.nov.

♀.—Length of body, 3·5 mm. ; length of wing, 1·8 mm. ; length of antenna, 0·6 mm. ; width of head, 0·43 mm.

Head dull brown, the antennal depression creamy-white, clothed with dark brown hairs on the occiput ; clypeus rather paler brown, with four dark brown hairs on each side of the middle line ; eyes relatively not very widely separated, the space between them almost one-fifth the greatest width of the head and devoid of hairs. Proboscis pale brown. Palpi (fig. 2, *f*) pale brown, with brown hairs ; third and fourth segments elongate, subequal ; the third strongly incrassate, with a deep sensory pore, the orifice of which is very large and occupies almost the entire length of the inner side. *Antennae* moderately long, yellowish brown, with short pale brown hairs and slightly curved, pointed, transparent spines ; segments 4 to 13 subspherical to oval, the length varying from 0·8 to 1·3 times the breadth ; terminal segment (fig. 5, *a*) elongate, equal in length to the preceding two and one-third segments together. *Thorax* : disc dark umber-brown, pollinose, clothed with short brown hairs ; prothoracic lobes and humeral callus yellowish brown ; scutellum and postscutellum rather darker than the disc, the former with three pairs of strong median bristles and two pairs of small lateral hairs ; pleurae and pectus dark umber-brown. *Wings* whitish, venation normal, the first and third veins (fig. 8, *d*) fused distally, not forming an interspace. *Legs* entirely brownish yellow, bearing pale brown hairs and, on some of the tarsal segments, stout blackish spines ; fore femora and tibiae slightly swollen and somewhat shortened, tibia of all the legs with an apical spur ; metatarsi each with two sub-ventral or ventro-lateral rows of strong spines,* the second and third tarsal segments of the fore and middle legs each with two apical spines, of hind legs wanting. Claws (fig. 4, *f*) of fore and middle legs equal, each with a large (at least half the length of the claw) strong tooth arising from the base. *Abdomen* waxen creamy white above and below, clothed with short hairs. Lamellae brownish yellow, approximately 0·25 times the length of the wing. Spermathecae two, rather narrowly oval ($65\mu \times 38\mu$), highly chitinised ; commencement of the duct chitinised for a very short distance.

Habitat. Siam : Patani Cape (*H. C. Robinson & N. Annandale*). One female (type) in the British Museum Collection.

This species is not closely allied to any of the known members of *Leptoconops* (*sens. lat.*) ; it agrees with *L. indicus* in regard to the structure of the claws, but may readily be separated therefrom by its relatively large size and the powerful spinose armature of its metatarsi. In the latter character and the reduction in length of the fore legs it suggests *Acanthoconops* (*q.v.*).

* The development of these spines has not proceeded uniformly, and although normally paired, the spine on one side is often much smaller than that on the other and may be represented by a strong bristle. The number of spines present on the same segments of corresponding legs therefore varies, and on the metatarsi of the single specimen available was—fore legs 18 and 15, middle legs 14 and 15, hind legs 9 and ? (the metatarsus of the corresponding leg missing).

Subgenus **Holoconops,** Kieff.

Holoconops, Kieff., Ann. Mus. Nat. Hung. xvi, p. 135 (1918).

This subgenus comprises those species of *Leptoconops* (*sens. lat.*) in which the ntennae of the female are composed of thirteen segments ; in all the known species he claws in this sex are simple and equal. The group was given generic rank by Kieffer, ;ho based its separation upon the structure of the female antennae and claws. Such a ombination of characters, however, cannot be maintained, since the structure of the laws is in no way peculiar, and this author's restriction of the type mentioned above o *Holoconops* is evidently due to a misconception. Kieffer designated *L. kerteszi*, Kieff., as his genotype, and, in a footnote, associated it with *L. flaviventris*, Kieff., . *hyalinipennis*, Kieff. (synonymous with *L. bezzii*, Noé), and *L. lacteipennis*, Kieff. ; ut the inclusion in this group of the second and third-named species is a palpable versight, as in his descriptions of them on preceding pages of the same article the ntennae are definitely stated to possess the full complement of segments (fourteen).

Three species of this subgenus are here recognised, but one (*L. interruptus*, End.) ; insufficiently described, and may subsequently prove identical with one of the thers. They are widely distributed, and have been recorded from Northern Africa, sia Minor, South West Africa and the United States of America.

eptoconops kerteszi, Kieff.

Leptoconops kerteszi, Kieff., Ann. Mus. Nat. Hung. vi, p. 576 (1908).

Mycterotypus laurae, Weiss, Arch. Inst. Pasteur de Tunis, pp. 25-32 (1912).

Mycterotypus laurae var. *peneti*, Langeron, Arch. de Parasit. xvi, pp. 282-301 (1913).

The synonymy given above is based upon examinations of specimens sent me as . *kerteszi* by Mr. F. C. Willcocks from Egypt, and of females of *L. laurae* sent me by [. A. Weiss from Tunis. *L. kerteszi* was described by Kieffer from specimens collected t Cairo, and the material received from Mr. Willcocks agrees in detail with this uthor's descriptions. Furthermore Kieffer, who is evidently unacquainted with . *laurae*, has recently (1918) recorded *L. kerteszi* from Tunis.

The following description is compiled from the Egyptian and Tunisian specimens eferred to above.

♀.—Length of body (six specimens), 1·8–2·1 mm. ; length of wing, 1·1–1·3 mm. ; gth of antenna, 0·33–0·42 mm. ; width of head, 0·31–0·34 mm.

Head shining black, the antennal depressions pale buff, sparsely clothed on the tex and occiput with short black hairs ; clypeus shining black, with three pairs of k hairs ; eyes relatively widely separated, the space between them being approxi-tely two-fifths the width of the head. Proboscis dark brown or black. Palpi fig. 2, *d*) dark brown, with brown hairs ; third segment very strongly swollen, h a large oval pore situated near the middle, fourth segment slightly inflated ally, scarcely shorter than the third. *Antennae* (*cf.* fig. 5, *g*) dark brown, with her long (about twice the length of the segment) pale brown hairs ; fourth to twelfth ments transversely oval to spherical, from 0·8 to 1·0 as long as broad ; thirteenth ment equal in length to the preceding three and one-third to four segments together. *rax* entirely shining black, with short black hairs ; scutellum with two pairs of tles. *Wings* white, iridescent ; venation normal, the anterior veins not quite ching the middle of the anterior border and arranged as in fig. 8, *h* ; fifth vein rcating slightly before the extremities of the costa and third veins. Halteres. itish. *Legs* dark brown, clothed with dark hairs ; metatarsi of the hind legs paler wn, with short brownish yellow hairs ; fore and middle metatarsi with a basal and cal pair of slender, pointed spines, and a few (one to four) central, usually unpaired,

spines; hind metatarsi and second segments of all the legs with a pair of similar spines at the extremities. Claws (*cf.* fig. 4, *c*) simple and equal, each with a short bristle arising from the base. *Abdomen* dark brown, the margins of some of the tergites narrowly grey, sparsely clothed with short brown hairs. Lamellae pale brown, 0·25 the length of the wing. Spermathecae two (a third very small, narrowly oval one is often present), heavily chitinised, obovate, ($47\mu \times 36\mu$); a minute portion only of the duct chitinised.

The male was described by Weiss, who stated that it was uniformly darker in colour than the female, and gave the following measurements:—Length of body, 1·5 mm.; length of antennae (barely), 0·5 mm. Judging by this author's description and figures, it presents certain striking morphological differences from those males which have been associated with species of *Leptoconops* (*sens. str.*). The eyes are said to meet at a point above; the palpal segments are depicted as subequal in length and about three times as long as wide; the fourth antennal segment almost twice as long as the fifth, the fifth to twelfth short and broad, subequal, the last three segments elongate, but the thirteenth almost equal in length to the fourteenth and fifteenth taken together; and the wings with reduced venation—the fourth vein being absent.

Habitat. Egypt: Cairo, Behera, Wadi Natroun, Sakkara (*Willcocks*). Tunis: Tabeditt (*Weiss*).

Willcocks (1917) states that the species was first sent from Behera in March 1907, and that it is common at certain seasons in Wadi Natroun, and in the autumn, when the Nile is in flood, from Mena House to Sakkara.

Leptoconops kerteszi var. **peneti,** Langeron.

♀.—Length of body, 1·5–1·8 mm.; length of wing, 1·06 mm.; length of antenna (from figure), 0·45 mm.

According to Langeron this variety differs from the specimens (type series) of *M. laurae* in the Paris Museum principally in being larger, darker, and possessing more numerous and stronger bristles and spines. In particular, he compares the development and exact arrangement of the metatarsal spines in the two forms. He also maintains that biological differences exist: the variety appears to persist later in the year, occurs in a more southerly region, and at a much lower altitude than is recorded by Weiss for the type form. *M. laurae* came from a mountainous region (altitude 500 metres), while the var. *peneti* was found in the desert (mean altitude 30 metres), in the marshes lying between the oases of El Hamma and the Shott Gharsa.

In view of the individual variation in regard to size, and number and arrangement of the metatarsal spines observed in a series of specimens of *L. kerteszi*, the distinguishing points cited by Langeron can scarcely be granted even varietal value; but in this author's excellent and detailed description of his specimens, mention is made of a character which is of much greater importance, and which raises doubt regarding its specific identity. The ungual formula is stated to be 0·1—0·1—0·1, and the external claw of each leg is said to bear a small basal tooth. Such a condition occurs in no other species of *Leptoconops*, and therefore, if Langeron's interpretation be correct, the form should be easily recognised and would deserve specific rank. It should be noted, however, that in some species the base of the claw is relatively broad and projects slightly ventrally, so that, in certain positions, a minute basal tooth appears to be present.

Leptoconops kerteszi var. **americanus,** nov.

♀.—Length of body (three specimens), 1·75 mm.; length of wing, 1·1 mm.; length of antenna, 0·32 mm.; width of head, 0·30 mm.

In spite of their widely distant places of origin I have been unable to find any satisfactory characters for separating specimens from Utah (received through the

:indness of Professor L. O. Howard and Dr. J. M. Aldrich) from typical examples of :. *kerteszi*. Indeed, allowing for minute differences which come within the range of ndividual variation, the only distinguishing details appear to be the formation of an nterspace by the first and third veins (fig. 8, *k*) and the slightly different form of the permathecae. These are almost spherical in the Utah specimens, whereas they are bovate in the Mediterranean examples. Males of both forms, when forthcoming and compared, may possibly reveal distinctive antennal or genital characters, but until uch time the American form can, at the most, be accorded varietal rank.

Habitat. United States of America: Utah, Salt Lake, June, " biting devilishly " H. S. Barber). Three females (cotypes) in the collections of the United States ational Museum and Liverpool School of Tropical Medicine.

eptoconops lacteipennis, Kieff.

Leptoconops lacteipennis, Kieff., Ann. Mus. Nat. Hung. xvi, p. 32 (1918).

This species, described from a female captured in Tunis, apparently differs from . *kerteszi* chiefly in the metatarsi being devoid of spines, the segments of the flagellum ore uniformly transversely oval, and the fifth tarsal segment shorter than the fourth. he last character should enable the species to be identified without difficulty, since,) far as I am aware, it is unique in this respect.

The more important of the specific characters given by Kieffer are as follows:—

♀.—Black. Fourth to twelfth antennal segments transverse (from the figure ccompanying the description, the length varies from 0·6 to 0·7 times the breadth), iirteenth segment slightly longer than the three preceding segments together. Iesonotum shining. Halteres white. Wings milky white, extending almost to the p of the abdomen; third vein reaching almost to the middle of the wing, fifth vein ifurcating slightly before the extremity of the third vein. Legs black, without pines, tarsi brown; tarsal segments 1 to 4 gradually decreasing in length, the fifth egment shorter than the fourth. Claws simple, equal, each with a bristle arising om the base. Abdomen brownish black. Length, 2 mm.

eptoconops interruptus, End.

Mycterotypus interruptus, End., Denks. Med. Ges. Jena, i, pp. 133–162 (1908).

The description of this species given by Enderlein relates largely to characters of a eneral nature, and details which, in the light of our present knowledge of the group, ust be considered of value in separating such closely allied forms receive little ttention. Nevertheless, with the help of the figures accompanying the description, would appear that *L. interruptus* is very close to, if not identical with, *L. kerteszi*. Veiss (1912) observed the close relationship existing between these species, and specially noted the affinities existing in regard to the spinose armature of the ietatarsi and the structure of the antennae. Since, however, the exact arrangement f the metatarsal spines is not of specific importance, it seems that the only ingible differential character is afforded by the antennae. Enderlein states that ie third to twelfth segments are spherical, and that the last segment is twice as ng as broad; this would indicate, also, that the terminal segment was approximately qual in length to the two preceding segments together. In *L. kerteszi* the last egment is at least three times as long as broad, and is equal in length to the three to our preceding segments.

A re-examination of the type or the examination of further material from South Vest Africa (Enderlein's example came from Rooibank, hinterland of Walfish Bay) is ecessary, before a decision regarding the validity of one or both of these species can e made.

Genus **Acanthoconops**, nov.*

Frons clothed with bristles or spines. Antennae in the female pilose, composed of fourteen segments, the fourth to thirteenth short and broad, subspherical, the fourteenth elongate, subconical. Eyes, palpi, proboscis and wings as in *Leptoconops*, Sk. (*sens. lat.*). Fore legs relatively short, the fore and hind femora and tibiae strongly incrassate, the middle femora moderately incrassate; claws equal, each with a tooth arising from the base; empodium bristle-like. Ovipositor somewhat triangular, very short, considerably broader than long.

Genotype: *A. spinosifrons*, sp. nov.

This genus is very closely allied to *Leptoconops* (*sens. lat.*), but may readily be distinguished by the remarkably short ovipositor (fig. 9), and by the vestiture of the head. In *Leptoconops* (*sens. lat.*) the whole of the frons (*i.e.*, the wide area extending from the vertex to the clypeus) is bare, or, at most, possesses a single pair of bristles between the eyes, while in *Acanthoconops* it bears numerous spines or bristles (*cf.* fig. 1, *a* and *b*). Further, in the two species of *Acanthoconops* at present known the fore legs are noticeably shortened, and the metatarsi of all the legs armed with formidable spines. The ratio of the combined lengths of the femora and tibiae of the fore legs to those of the hind legs is 1 : 1·5, or but slightly less; in *Leptoconops* this ratio is rarely more than 1 : 1·2, and not infrequently is 1 : 1. In this connection it may be of interest to note that, among the members of the latter genus, the ratio given for *Acanthoconops* is (so far as can be determined from the material available) most nearly approached in the case of *L. siamensis*, sp. n. In this species, which also possesses powerful spines on the metatarsi, the ratio is almost 1 : 1·4.

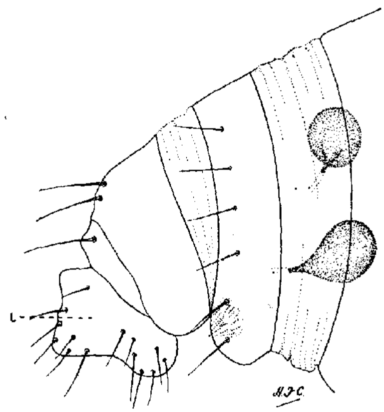


Fig. 9. Extremity of abdomen of *Acanthoconops spinosifrons*, sp. n., ♀, showing lamellae (*l*); side view (× 220 circa).

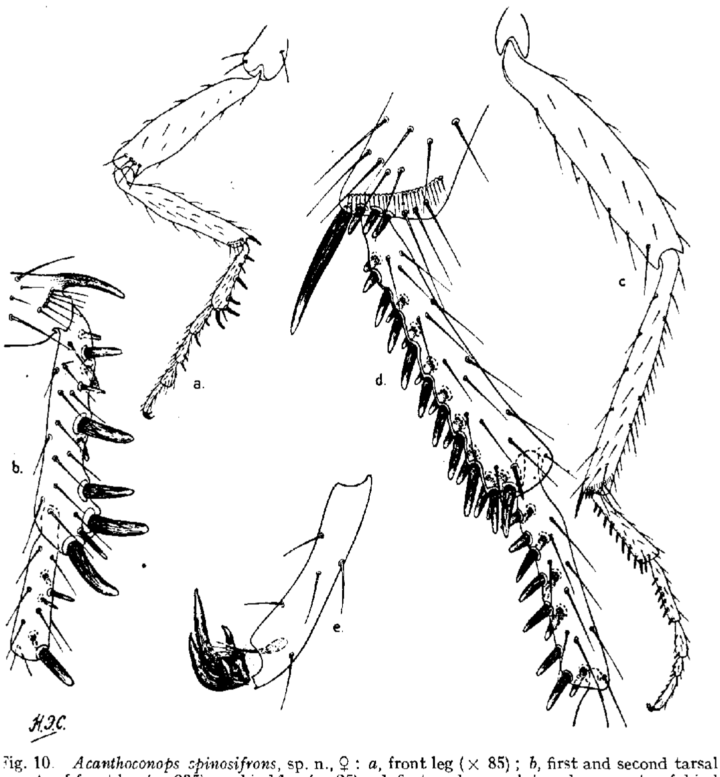
Acanthoconops spinosifrons, sp. nov.

♀.—Length of body (two specimens mounted in Canada balsam), 2·3 mm.; length of wing, 1·2 mm.; length of antenna, 0·35 mm.; width of head, 0·32 mm.

Head dull black, with short, stout, pointed, backwardly directed, tuberculate spines scattered over the occiput and frons, on the lower portion of which they are more numerous; clypeus shining dark brown, with a group of spines centrally and a

* ακανθα spine, and κωνωψ gnat.

ew (three pairs) relatively short black hairs ; eyes widely separated above and below, he space between them at the vertex being rather more than one-third the greatest vidth of the head. Proboscis dark brown. Palpi (fig. 2, *e*) dark brown, the apical egment yellowish brown, clothed with short dark hairs ; apparently composed of hree segments, the two small basal segments being almost fused together ; orifice of the sensory pit in the third segment small, subcircular, situated in the roximal third. *Antennae* (fig. 5, *f*) relatively short, dark brown, with short glistening airs and short, straight or slightly curved spines ; segments 4 to 13 transversely val to subspherical, the length varying from 0·6 to 0·8 of the breadth, the fourteenth



ig. 10. *Acanthoconops spinosifrons*, sp. n., ♀ : *a*, front leg (× 85) ; *b*, first and second tarsal ments of front leg (× 295) ; *c*, hind leg (× 85) ; *d*, first and second tarsal segments of hind (× 295) ; *e*, fifth tarsal segment of hind leg (× 550).

gment equal in length to the preceding two and one-half segments together. *Thorax* d scutellum shining black, the dorsum clothed with short brown hairs ; scutellum aring two pairs of large, and one or two pairs of small bristles ; pleurae and pectus ining black. *Wings* glassy, strongly iridescent ; the anterior veins as shown in . 8, *l*, the fifth vein bifurcating almost immediately below the extremity of the ird vein. Halteres with white knobs and infuscated stems. *Legs* (fig. 10) pale own, the distal two-thirds or three-fourths of the femora, and the distal third of the e and hind tibiae, black, clothed with brown hairs ; tibiae each with a strong ical spur, fore tibiae incrassate, hind tibiae with five strong, blunt, black spines on

the outer side at the apex, and with three of the bristles of the posterior transverse distal row (situated on the inner aspect) replaced by similar but smaller spines; metatarsi, particularly those of the hind legs, short, fore and hind metatarsi incrassate; fore and hind tarsi with stout, blunt black spines arranged as shown in fig. 10, middle tarsi with six or seven pairs of similar spines on the first segment and the apical bristles of the second and third segments differentiated—spine-like. Claws (fig. 10, *e*) equal, the basal tooth stout. *Abdomen* translucent creamy white, but appearing in engorged or partly fed specimens dark brown or cream-coloured, with dark central bands on the proximal segments; clothed with pale hairs. Lamellae creamy white, clothed with pale hairs. Spermathecae two in number, heavily chitinised, oval ($53\mu \times 37\mu$); the commencement of the duct chitinised for a relatively long distance (18μ).

Habitat. Zanzibar (*Dr. W. M. Aders*), seven females (including three cotypes). The labels attached to the specimens bear the following data: on buffalo; Pigaduri, Zanzibar, 13.iv.19. In the collection of the Imperial Bureau of Entomology.

Acanthoconops albiventris, de Meijere.

Leptoconops albiventris, de Meijere, Tijds. voor Ent. lviii, p. 98 (1915).

Leptoconops spinosipes, Kieff., Ann. Mus. Nat. Hung. xv, p. 190 (1917).

♀.—Length of body (two specimens), 1·8 mm.; length of wing, 1·0 mm.; length of antenna, 0·3 mm.; width of head, 0·32 mm.

Through the courtesy of Professor de Meijere, I have been able to examine females of this species, which was described by him from specimens collected in New Guinea. This author noticed and commented upon the unusual form of the lamellae, but retained the species in *Leptoconops*, and apparently did not observe closely the arrangement of the hairs on the head; this he stated was "kaum behaart." *A. albiventris* is closely allied to the preceding species, but is smaller, and possesses somewhat less powerful, though similarly arranged, spines on the legs. Morphologically, it may readily be separated from *A. spinosifrons* by (1) the frons bearing numerous short hairs or bristles instead of spines; (2) the terminal segment of the antennae being relatively longer (equal in length to the preceding three and one-third segments instead of the preceding two and one-half); (3) the bristles forming the posterior transverse distal row on the hind tibiae all being normal, none replaced by spines; (4) the hind metatarsus being relatively longer (about one-half the length of the tibiae, whereas in *A. spinosifrons* it is about one-third the length); and (5) the tooth of the claws being distinctly smaller.

The synonymy given above seems extremely probable from a comparison of the descriptions, and in view of the fact that Kieffer's specimens also came from New Guinea (Tamara, Berlinhafen). Discrepancies in the descriptions are slight, and Kieffer's statement that the abdomen is red, sometimes white, with brownish markings, is of little consequence, as it suggests that some (possibly most) of his examples were wholly or partly engorged with blood.

This species appears to be a vicious biter and, at times, a serious pest in parts of New Guinea; K. Gjellemp, the collector of de Meijere's material, attached the following information to the specimens—"An der Mundung des Sermowai-Flusses in sehr grosser Anzahl vorhanden und durch ihr Stechen eine grosse Plage bildend, 16 Mai 1911."

The distinguishing characters of the known species (females) of *Leptoconops* (*sens. lat.*) and *Acanthoconops* are summarised in the following table.

(1) Lamellae elongate; frons bare or with a single pair of hairs between the eyes (*Leptoconops*, *sens. lat.*) 2

Lamellae very short; frons with numerous spines or hairs (*Acanthoconops*) 17

(2) Antennae composed of fourteen segments (*Leptoconops, sens. str.*) 3
Antennae composed of thirteen segments (*Holoconops*, subgen.) 13

(3) Claws simple 4
Claws toothed 10

(4) Metatarsi with distinct spines 5
Metatarsi without spines (excluding the pair at the apex) 6

(5) Abdomen whitish or yellow; lamellae approximately one-fifth the length of the wing .. .. *irritans*, Noé (p. 14).
Abdomen dark brown; lamellae approximately one-third the length of the wing .. .. *braziliensis*, Lutz (p. 13).

(6) Fifth vein bifurcating considerably beyond extremity of costa .. .. *rhodesiensis*, sp. n. (p. 14).
Fifth vein bifurcating before or below extremity of costa 7

(7) Third palpal segment greatly swollen; antennal segments 4–13 distinctly broader than long (American species) .. .. *torrens*, Twns. (p. 15).
Third palpal segment elongate, slightly swollen; antennal segments 4–13 subspherical or longer than broad (Australian species) 8

(8) Smaller species (wing length 1.3 mm.); last antennal segment less than twice as broad as long .. .. *stygius*, Skuse (p. 10).
Larger species (wing length 2·0 mm.); last antennal segment more than three times as broad as long 9

(9) Antennae very long, last segment at least six times as long as broad .. *longicornis*, sp. n. (p. 11).
Antennae shorter, last segment at most three and one-half times as broad as long.. .. .. *grandis*, sp. n. (p. 12).

(10) Metatarsi with very large spines .. .. .. *siamensis*, sp. n. (p. 20).
Metatarsi without spines (excluding the pair at the apex) 11

(11) Antennal segments 4–13 transversely oval to spherical, the last segment slightly longer than the two preceding together .. *bezzii*, Noé (p. 17).
Antennal segments 4–13 all broader than long, the last segment as long as the three or four preceding together 12

(12) Abdomen yellow; last antennal segment as long as the three preceding together .. .. *flaviventris*, Kieff. (p. 18).
Abdomen red; last antennal segment as long as the four preceding *indicus*, Kieff. (p. 19).

(13) Metatarsi without spines; fifth tarsal segment shorter than fourth .. *lacteipennis*, Kieff. (p. 23).
Metatarsi with distinct spines; fifth tarsal segment longer than fourth .. 14

(14) Last antennal segment twice as long as broad, segments 4–12 spherical .. *interruptus*, End. (p. 23).
Last antennal segment three to four times as long as broad, segments 4–12 transversely oval to spherical 15

(15) Claws equal, one simple, the other with a minute basal tooth .. .. *kerteszi* var. *peneti*, Langeron (p. 22).
Claws equal and simple 16

(16) Spermathecae obovate, narrow anteriorly (Mediterranean Region) .. *kerteszi*, Kieff. (p. 21).
Spermathecae subspherical (America) *kerteszi* var. *americanus*, n. (p. 22).

(17) Frons spiny (Tropical Africa) .. .. .. *spinosifrons*, sp. n. (p. 24).
Frons hairy (New Guinea) .. .. .. *albiventris*, Meij. (p. 26).

References.

CASTELLANI, A. & CHALMERS, A. J. (1913). A Manual of Tropical Medicine. London, 2nd ed., p. 678.

,, ,, (1919). *Ibid.* 3rd ed., p. 803.

CHATTON, E. & BLANC, G. (1917). Notes et réflexions sur les Toxoplasmes et la Toxoplasmose du Gondi (*Toxoplasma gundii,* Nicolle et Marceaux, 1909).—Arch. Inst. Past. Tunis, x., pp. 1–40.

GRASSI, B. (1901). Die Malaria: Studien eines Zoologen. Jena, pp. 118–122.

JOHANNSEN, O. A. (1905). Aquatic Nematocerous Diptera, II.—N.Y. Sta. Mus. Bull. No. 86, pp. 94–96.

KIEFFER, J. J. (1906). Chironomidae. Genera Insectorum. Wytsman. 42e fasc. Diptera, pp. 44–48.

,, (1908). Description d'une espèce nouvelle de Chironomides d'Egypte. —Ann. Mus. Nat. Hung. vi.

,, (1917). Chironomidae d'Australie.—*Ibid.* xv, pp. 189–191.

,, (1918). Chironomides d'Afrique et d'Asie.—*Ibid.* xvi, pp. 31–136.

LANGERON, M. (1913.) *Mycterotypus laurae*; description d'une variété nouvelle (*M. laurae* var. *peneti*).—Arch. Parasit. xvi, pp. 282–304.

LUTZ, A. (1912). Contribuição para o estudo das Ceratopogoninas haematofagas do Brazil.—Mem. Inst. Osw. Cruz, iv, p. 24.

,, (1913). Do.—*Ibid,* v, pp. 45–72.

MALLOCH, J. R. (1915). The Chironomidae, or Midges, of Illinois, with particular reference to the species occurring in the Illinois River.—Bull. Ill. Sta. Lab. Nat. Hist. x, Art. 6, p. 401.

MEIJERE, J. C. H. de (1915.) Diptera aus Nord-Neu Guinea.—Tijds. voor Ent. lviii, pp. 98–101.

MIK (1894). Wiener Ent. Zeit. xiii, p. 164.

NOÉ, G. (1905). Un nuovo genere appartenente alla famiglia Chironomidae.—Atti. della Reale Accad. dei Lincei, Ser. 5, Rendiconti, xiv, pp. 114–120.

,, (1907). Due nuove specie di Ditteri appartenenti ad un genere nuovo.—Arch. Zool. Napoli, iii, pp. 101–164.

PRATT, F. C. (1907). Notes on "Punkies."—U.S. Dept. Agric. Bur. Ent. Bull. No. 64, part 3, pp. 23–28.

SAMBON, L. W. (1913). The Causation of Pellagra: a Contribution to the Discussion on Dr. Sandwith's Paper.—Trans. Soc. Trop. Med. & Hyg. vi, pp. 231–241.

SKUSE, A. A. (1890). Diptera of Australia. Part VI. The Chironomidae.—Proc. Linn. Soc. N.S.W. (2nd Ser.), iv, p. 288.

TOWNSEND, C. H. T. (1893). An interesting Blood-sucking Gnat of the family Chironomidae.—Psyche, vi, p. 369–371.

WEISS, A. (1912). *Mycterotypus laurae*, n. sp., Chironomide nouveau du Sud Tunisien. —Arch. Inst. Past. Tunis, pp. 25–32.

WILLCOCKS, F. C. (1918). Notes on some Insects found in Egypt of Medical and Veterinary Interest.—Bull. Soc. Ent. d'Egypte, 3rd fasc., July-Sept., p. 84.

MOSQUITO BREEDING IN SALINE WATERS.

By Andrew Balfour, C.B., C.M.G., M.D.

Director-in-Chief, Wellcome Bureau of Scientific Research.

In the " Bulletin of Entomological Research " for December 1920 Dr. J. M. Dalziel leals in a most interesting and instructive way with the various, and sometimes curious preeding-places of mosquitos in Lagos. He mentions the occurrence of mosquito arvae in saline waters, and in a foot-note refers to a number of salt-water species.

The subject of mosquitos breeding in salt and brackish waters possesses not only considerable scientific interest, but is of practical importance in anti-malarial work, for the suggestion has frequently been made to abolish ordinary mosquito breeding-places by the introduction of salt or of sea-water, and in some instances this procedure has actually been carried into effect. As will be seen, in the case of certain species of mosquitos it is useless or worse than useless.

Moreover, there is the question of the efficiency of larvicides in saline waters, a matter to which attention has been directed, but on which, so far as I know, our nformation is still defective.

It may therefore be of interest to refer a little more fully to the subject than Dr. Dalziel has done, although at the present time I am unable to deal exhaustively with the matter, and, after a few remarks, propose merely to supply some annotated references supplementary to those furnished by Dr. Dalziel, and dealing almost entirely with mosquitos known to be vectors of disease.

I hope that Mr. MacGregor, in charge of our Entomological Field Laboratory at Wisley, in Surrey, may be able to carry out some research on the question in the ensuing spring and summer, so far as it concerns indigenous species of mosquitos.

My attention was first specially directed to the subject when Mr. Harold King, the Entomologist of the Wellcome Tropical Research Laboratories at Khartoum, found *Culex sitiens*, Wiedemann (*salus*, Theobald), larvae in sea-water at Port Sudan, a fact to which Dr. Dalziel refers in his paper, and when, at Khartoum, I found *Anopheles* (*Pyretophorus*) *costalis*, Loew, breeding freely in brackish pools formed by seepage through the " weeping soil " of irrigation channels in Khartoum North. I had the water of these pools analysed, but unfortunately cannot find the record. I think, however, I am correct in saying that it contained at least 2 per cent. of common salt.

Hence this Anopheline can breed in waters similar to those in which, as Dr. Dalziel ientions, Willcocks in Egypt found the larvae of *Anopheles multicolor*, Camboulin, r, as it used to be called, *Pyretophorus cleopatrae*. This is of interest in view of ie fact that Graham recommended the salting of water containing the larvae of *. costalis*. He added common salt in the proportion of 3 per cent., and found that it aused disintegration and precipitation of the motile algae upon which the larvae ed. The latter, being thus deprived of their natural food, become cannibalistic. alt, he says, in lesser concentration appears to inhibit the growth of young larvae, robably by diminishing their food supply, but seems to hasten the fully-grown larvae, hich become pupae more rapidly than usual.

As a matter of fact Dutton in 1902 had already shown that in the Gambia *. costalis* could breed in salt-water pools. Its larvae were found along with those of *ulex thalassius*, Theobald.

Apparently Grassi in Italy was the first to direct attention to Anophelines breeding sea-water. Nuttall, Cobbet and Strangeways-Pigg took the larvae of *Anopheles aculipennis*, Meigen, in brackish water in England—twice in ditches, four times in ols—and Christophers and Stephens discovered Anopheline larvae in brackish pools Accra containing 0·6 per cent. salt.

Amongst the more important of the earlier investigations is that by de Vogel in the Dutch East Indies. As Howard, Dyar and Knab point out, he disproved certain conclusions of the Italian authors Perrone and Vivante, who stated that the maximum proportion of sodium chloride in water which the larvae of Anophelines could resist was under 2 per cent. Working chiefly with the larvae of *A. rossi*, Giles, de Vogel found that a considerably higher percentage of sodium chloride, *i.e.*, as much as 2·88, was not detrimental. His summary was as follows:—

"1. There are species of *Anopheles* which can live very well in sea-water.

"2. These mosquitos lay eggs which develop even in sea-water which has been evaporated to half its original quantity.

"3. These larvae in the gradually evaporating pools of sea-water can stand an evaporation of the water to one-third of its bulk, but do not appear to transform to adults if the concentration be greater than this.

"4. The larvae coming from eggs laid in sea-water of high concentration can accomplish their entire metamorphoses in almost the normal time. This is true even when the water has such concentration that the development of larvae originally hatching in unconcentrated sea-water would be retarded by this salt water."

Later work by Carruthers and Christophers in the Andamans and also by Banks in the Philippines and Swellengrebel in Java, suggests that de Vogel was probably dealing with *A. ludlowi*, Theobald, rather than with *A. rossi*, the two mosquitos being very similar.

A comparatively early record is that by Foley and Yvernault, who, in 1907, found *Pyretophorus chaudoyei*, Theobald, breeding in Algerian waters of which the salinity was greater than that of sea-water. *P. chaudoyei* is now called *A. multicolor*, an Anopheline which comes very near *A. hispaniola*, Theobald, which, again, is probably identical with the well-known Egyptian species *A. turkhudi*, Liston. As regards the last-named, Gough has recorded the occurrence of its larvae in a brook of highly saline water at Helouan, and succeeded in rearing them from water containing 2 per cent. of salt. On the other hand Willcocks (*loc. cit.*) found that a 1 per cent. salt solution proved fatal to the larvae of *A.* (*Cellia*) *pharoensis*, Theobald, a common Anopheline of Egypt.

Banks in 1908 showed that in the Philippines *A. ludlowi*, Theobald, a mosquito mentioned by Dr. Dalziel in relation to the Andamans, breeds in both salt and fresh water, and that in certain places they were present in water strongly impregnated with lime and also containing much aluminium sulphate.

Clerc in France found the larvae of a Culicine, *Ochlerotatus*, (*Culicada*) *cantans*, Meigen, in sea-water containing 44 grammes of chloride of sodium to the litre, and recorded his observations in 1909. He noted that these larvae survive when transferred to fresh water, whereas, on the other hand, if the young larvae of *A. maculipennis* are placed in salt water they die. The older larvae, however, survive and become pupae and imagines.

In 1910 Gholap at Bombay discovered the larvae of *A. stephensi*, Rothwell, in sea-water. The ponds in which they were found contained vegetable growths.

North American work on the subject, so far as Anophelines are concerned, includes the observations of Chapin, who in Rhode Island found *Anopheles* larvae flourishing in brackish coastal waters, and those of Smith on the larvae of *A. quadrimaculatus*, Say, in the saline waters of New Jersey, and the records demonstrating the breeding of *A. crucians*, Wiedemann, in similar localities both in New Jersey and Louisiana.

Stegomyia fasciata, Fabricius, figures in the list of mosquitos given by Dr. Dalziel as breeding in boats and canoes, the water in which was for the most part brackish.

Hence it is of interest to note that in Somaliland Drake-Brockman recorded the co-existence of *Stegomyia* larvae with those of *Culex sitiens,* and stated that brackish well-water was acceptable to the former.

Macfie experimented with the larvae of *Stegomyia fasciata* at Lagos in the hope of finding that common salt might be used as a larvicide in the case of this mosquito. He showed that as regards domestic utensils the saline solution required to be of a strength of 2 per cent. to ensure destruction of the larvae. Water containing 0·5 per cent. of sodium chloride had no appreciable effect upon them.

Fielding, working at Townsville, Queensland, found that the female *Stegomyia fasciata* oviposited in 70 per cent. sea-water.

Darling demonstrated the fact that in Panama *Stegomyia fasciata* could breed in brackish water of varying chlorine content and that such water could also harbour the aquatic stages of *A. pseudopunctipennis,* Theobald, *A. malefactor,* Dyar & Knab, and *Culex taeniorhynchus,* Wiedemann. In swamps containing 80 per cent. and more of sea-water he found the larvae of *A. albimanus,* Wiedemann, and *A. tarsimaculatus,* Goeldi, present in enormous numbers. Similar observations as regards *A. albimanus* were also made by Jennings of the Isthmian Canal Commission.

According to Peryassú the larvae of *A. argyritarsis,* Robineau-Desvoidy, in Brazil are found in strongly brackish water as well as in fresh water.

Howard, Dyar and Knab mention that certain Brazilian observers, experimenting with the larvae of *A. albimanus* and *A. argyritarsis,* " found that in slightly brackish water imagos were produced in a normal manner. In a mixture of 19 per cent. of sea-water with fresh water only a very small proportion of larvae transformed to imagos. Beyond this the larvae failed to pupate ; with 20 per cent. sea-water some of the larvae survived three days ; with 30 per cent. all died after one day."

Recent work by Taylor and Fielding in Queensland, Australia, shows that *A. annulipes,* Walker, is occasionally found breeding in salt waters.

The latest research into the question of the occurrence of the larvae of Anophelines in saline waters appears to be that by Sella, who had charge of the anti-malaria campaign at Fiumicino, near Rome. His observations were carried out on the larvae of *Anopheles maculipennis* or, as he calls it, *A. claviger,* and showed that a salinity up to 6–7 per 1,000 of sodium chloride was without effect. Laboratory experiments were also conducted, which indicated that the development of larvae is inhibited at an early stage by concentrations of above 13–14 per 1,000, and that even those exceeding 9 per 1,000 are no longer favourable to development. Pupae, however, are able to tolerate a very strong concentration. From the point of view of the employment of brackish waters in anti-malarial work it is interesting to note that the investigations showed that solutions exceeding 20 per cent. must be employed in order to ensure destruction within 10 hours, and exceeding 18 per cent. to obtain this result within 24 hours. Further, it has been shown that larvae which have been subjected to the action of the saline solution for several hours, if transported into fresh water before they are dead, will survive. Apparently, to judge from cage experiments, adult Anophelines are not influenced in laying by the mere salinity of the water.

So far as *Stegomyia fasciata* is concerned, its behaviour as regards brackish waters and sea-water has also formed the study of French and Brazilian observers, as recorded by Howard, Dyar and Knab in their important and comprehensive work on the mosquitos of North America.

Dr. Dalziel's note on the various species of *Culex* found breeding in the coastal salt marshes of the United States of America doubtless refers to the observations of Chidester, who made an exhaustive study of the subject.

As regards the action of larvicides in saline waters the experiments of Jacob in the Panama Canal Zone may be cited. Employing the well-known preparation devised for use in that area and consisting of so-called "crude carbolic acid," resin and caustic soda, he proved by laboratory tests that the mineral salts in the salt water do not lessen the toxicity of the larvicide. Moreover, if the larvicide be added as an emulsion (and it is essential that this should be the case, for the sodium salts of the cresols remain insoluble in sea-water), its entire quantity remains on the surface, where it is found deadly to mosquito larvae. Jacob sums up to the effect that

> "When all other conditions are the same, the larvicide applied in an emulsified state is more efficient in brackish water than it is in fresh water, and when brackish water is to be treated, the area of the surface of the water is the only factor necessary to be considered in determining the quantity of larvicide to be used."

Perry, commenting on this work, stated that his experience in the field confirmed the above results.

I have not been able to find records as regards the use of other larvicides in brackish waters, but lack of time has prevented an exhaustive search of the literature, in which, however, I believe there are but few references to the subject.

Mosquito larvae have been found in waters containing chemical constituents other than the marine salts, for example, aluminium sulphate, as already mentioned. Some of them, indeed, even survive in solutions which *a priori* one would imagine should speedily kill them. A consideration of these strange and sometimes sulphurous nurseries would, however, lead us too far afield, but it might well form the subject of another paper containing statements which, though perfectly true, might easily be regarded as incredible.

References.

Balfour, A...	—	Second Review. Supplement to 4th Report, Wellcome Tropical Research Laboratories, Khartoum, 1911, p. 201.
Banks, C. S.	A mosquito which breeds in salt and fresh water.	Philippine Jl. Sci., Section B, 1908, Vol. iii, No. 4, p. 335.
Carruthers	—	Presidential Address delivered by Surg.-Gen. C. P Lukis at the second meeting of the General Malaria Committee, Bombay, 16th Nov. 1911. (Abstract: Jl. Trop. Med. & Hyg. 1912, Vol. xv, p. 30.)
Chapin, C. V.	The origin and progress of the malarial fever now prevalent in New England.	Fisk Fund Prize Dissertation, No. 32. Providence, R.I. 1884.
Chidester, F. E.	The influence of salinity on the development of certain species of mosquito larvae and its bearing on the problem of the distribution of species.	New Jersey Agric. Expt. Sta. New Brunswick. Bull. 299. (Rev. in Rev. Appl. Entom. B, 1917, Vol. v., p. 103.)
Chidester, F. E., & Patterson, R.	The influence of various concentrations of sea-water on the viability of the salt-marsh mosquitoes, *Aëdes sollicitans* and *Aëdes cantator* (Dip.).	Entom. News, Philadelphia, vol. xxvii, No. 6, June 1916, p. 272. (Rev. in Rev. Appl. Ent. B, 1916, Vol. iv, p. 123.)

References—cont.

Christophers, S. R. ..	Malaria in the Andamans ..	Scientific Memoirs by Officers of the Medical and Sanitary Departments of the Government of India, Calcutta, 1912.
Clerc, A.	Contribution à l'étude des moustiques qui vivent dans l'eau salée.	C.R. Soc. Biol. 1909, Vol. lxvi, p. 120.
Dalziel, J. M.	Crab-holes, trees, and other mosquito sources in Lagos.	Bull. Entom. Res. 1920, Vol. xi, Part 3, p. 247.
Darling, S. T.	Studies in relation to malaria ..	Isthmian Canal Commission Laboratory Board of Health, Department of Sanitation, 1910.
De Vogel, W. T.	Anophélines dans l'eau de mer.	Atti della Soc. per gli Studi della Malaria, 1907, Vol. viii, p. 1.
Drake-Brockman, R. E. ..	Some notes on *Stegomyia fasciata* in the coast towns of British Somaliland.	Jl. London School Trop. Med. 1913, Vol. ii, Part 3, p. 166. (Rev. in Rev. Appl. Entom. 1914, Vol. ii, p. 7.)
Dutton, J. E.	Report of the malarial expedition to the Gambia, 1902.	Liverpool School of Trop. Med. Memoir No. 10.
Fielding, J. W.	—	Australian Inst. of Trop. Med. Townsville, Queensland. Yearly Report, Jan. 1 to Dec. 31, 1919, p. 7.
Foley, F. H., & Yvernault, A.	Anophélines dans l'eau salée ..	Bull. Soc. Path. Exot. 1908. Vol. i, p. 172.
Gholap, R. D.	Anopheles larvae breeding in salt water.	Ind. Med. Jl. June 1910, Vol. iv, No. 6. (Abstract: Jl. Trop. Med. & Hyg. 1910, Vol. xiii., p. 270.)
Gough, I. H.	Preliminary notes on Egyptian mosquitos.	Bull. Ent. Res., September, 1914, Vol. v, p. 133.
Graham, W. M.	The study of mosquito larvae..	Bull. Ent. Res., April 1910, Vol. i, p. 51.
Grassi, B.	—	Quoted by Howard, Dyar and Knab (*q.v.*), p. 228.
Howard, L. O., Dyar, H. G. & Knab, F.	The Mosquitoes of North and Central America and the West Indies.	Volume i, 1912, pp. 224–229.
Jacob, J. E.	The study of larvicides. I. The action of larvicides in brackish water.	Proc. Med. Assoc. Isth. Canal Zone, October 1912 – March 1913, Vol. v, Part 2, p. 86.
King, H. H.	Report on Economic Entomology.	Third Report. Wellcome Research Laboratories, Khartoum 1908, p. 206.
Macfie, J. W. S.	A note on the action of common salt on the larvae of *Stegomyia fasciata*.	Bull. Ent. Res., February 1914, Vol. iv, p. 339.

References—cont.

Nuttall, G. H. F., Cobbet, L. & Strangeways-Pigg, T.	Studies in relation to malaria. I. The geographical distribution of *Anopheles* in relation to the former distribution of ague in England.	Jl. Hygiene, 1901, Vol. i, p. 4.
Perrone, E.	Sui costumi delle larva delle zanzare del genere Anopheles in relazione con le bonifiche idrauliche.	Atti Soc. p. g. Studi della Malaria, 1901, Vol. ii, p. 33.
Perry, J. C.	(Discussion on Jacob's paper, *q.v.*)	Proc. Med. Assoc. Isth. Canal Zone, 1912–1913, Vol. v, Part 2, p. 92.
Peryassú, A. G.	Os culicideos do Brazil.. ..	Inst. de Manguinhos, Rio de Janeiro, 1908.
Smith, J. B.	—	Quoted by Howard, Dyar and Knab (*q.v.*), p. 228.
Sella, M.	The antimalarial campaign at Fiumicino (Rome), with epidemiological and biological notes	Internat. Jl. Pub. Health, 1920, Vol. i, p. 316.
Taylor, F. H., & Fielding, J. W.	—	Australian Inst. of Trop. Medicine. Half-Yearly Report from 1st July to 31st December1917, p. 6.
Vivante	—	Quoted by Howard, Dyar and Knab (*q.v.*), p. 224.
Willcocks, F. C.	A preliminary note on the presence of mosquitoes in Cairo and its environs.	Ann. Trop. Med. & Parasit. 1910, Vol. iii, p. 583.

ON SOME BORNEAN FIG-INSECTS (AGAONIDAE —HYMENOPTERA CHALCIDOIDEA).

By JAMES WATERSTON, B.D., B.Sc.

(Published by permission of the Trustees of the British Museum.)

The following notes deal with the AGAONIDAE represented in a small collection of fig insects formed in 1907–8, in Sarawak, by Mr. J. Hewitt, now Director of the Albany Museum, Grahamstown, South Africa.

Genus **Blastophaga**, Grav.

Blastophaga jacobsoni, Grnd.

Blastophaga jacobsoni, Grandi, Boll. Lab. Zool. Portici, x, pp. 126 and 127, 26th April 1916, and *ibid.* xii, pp. 21–32, figs. vii–x, 1917.

Four ♀♀ " From a fig."

BORNEO: Siol, Sarawak, viii. 1908 (*J. Hewitt*).

In none of these specimens is the antenna complete beyond the sixth joint. Dr. Grandi, who has at my request kindly compared this material with the type (which was described from fruit of *Ficus procera*, Reinw., var. *crassiramea*, King, from plants in the Botanical Garden, Buitenzorg, Java), is satisfied that it is referable to his species, although the first mid-tarsal is not longer than the second, and the pilosity of the thorax is not quite typical.

The range of *Ficus procera* and its var., so far as I can ascertain, is Java and Sumatra. The species may, however, have been introduced into Borneo.

Genus **Ceratosolen**, Mayr.

Ceratosolen hewitti, sp. nov.

♀.—Head wider (10 : 9) than long (deep). Clypeal lobes large and very prominent (fig. 1, *a*), central tooth short, keel distinct. Distance between the lower corner of the eye and the base of the mandible slightly longer than the depth of the eye. Antenna, length 0·9 mm. (fig. 1, *b*); the scape viewed from beneath (fig. 1, *c*) and outwardly shows a remarkable obliquely-set thickish edge or ridge ending abruptly at both extremities; process of the third joint (fig. 1, *b*, *d*) distinctly articulated, fourth joint short; sensoria of the funicle numerous, only shortly free distally, those on the inner aspect of the fifth joint being slightly broader than any others; spinose bristles on the inner surface of the pedicel (fig. 1 *d*) numerous and stout.

Trophi. Mandible with two small teeth and swollen along the anterior edge; its ventral surface with about five ridges. Appendage (2 : 1) short and broad, three-fourths as long as the mandible itself and half as broad, with five ridges. Stipes with one lateral bristle and no free splint.

Thorax. Protergum broadly concave posteriorly; free striated margin broad, narrower at the extremities; whole sclerite bristly—40 bristles, more or less, on each side of the mid line. Scutellum generally with three bristles along each furrow and 7–8 (minute) across the middle. Propodeon (fig. 1, *e*) with numerous bristles round the spiracle. Prepectus showing a number (6–8) of fine striae, antero-posteriorly directed, on the outer two-thirds. Mainly posteriorly, the mesosternum bears numerous bristles.

Forewings twice as long as broad, length about 1·125 mm. Submarginal: marginal: radius: postmarginal veins approximately in ratio 33 : 9 : 11 : 14. The

submarginal bears towards the base a clear pustule (before which 1–2 bristles may occur) without a bristle, but followed by five moderately long bristles, all on the proximal two-thirds of the vein. At the uprise to the marginal is one somewhat long

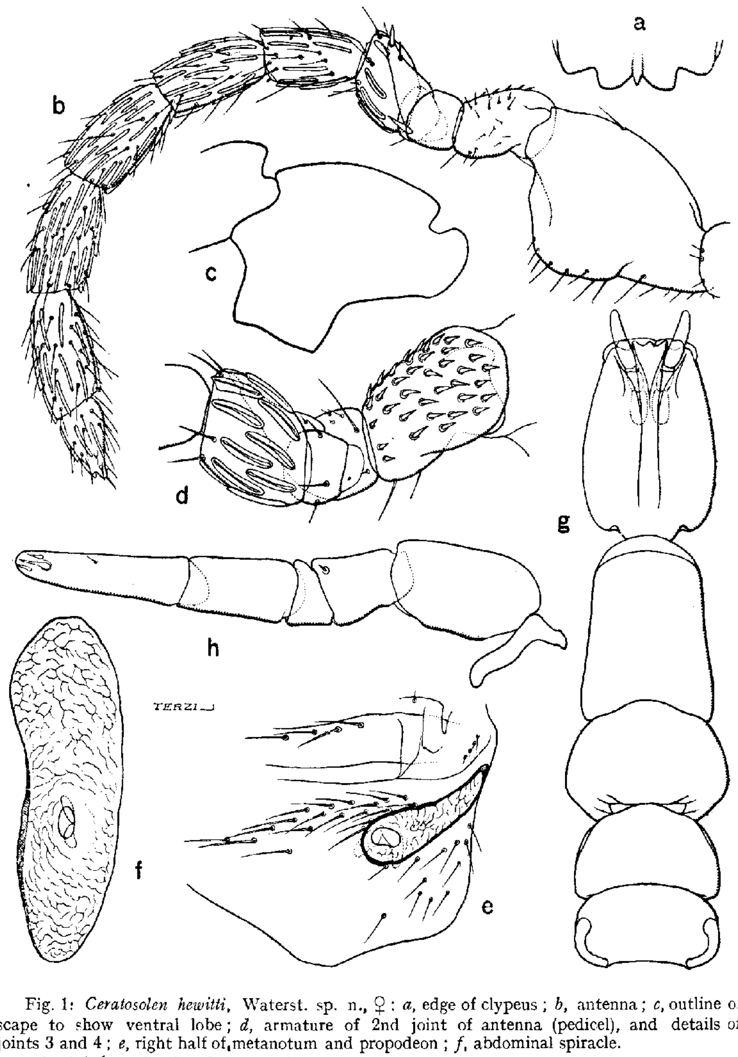


Fig. 1: *Ceratosolen hewitti*, Waterst. sp. n., ♀ : *a*, edge of clypeus ; *b*, antenna ; *c*, outline of scape to show ventral lobe ; *d*, armature of 2nd joint of antenna (pedicel), and details of joints 3 and 4 ; *e*, right half of metanotum and propodeon ; *f*, abdominal spiracle.
C hewitti ♂ : *g*, head and thorax ; *h*, antenna.

bristle and 3–4 clear pustules triangularly arranged. Up to the radius the marginal bears 7–8 bristles and the postmarginal 3–4 ; along the combined edges of marginal

and postmarginal stand about 20 bristles, some of which are double, *i.e.*, one rising from above and the other from below the membrane. Radius with 4–5 bristles and three clear pustules. Hindwing (7 : 2) 0·66 mm. long.

Legs. Fore coxa shorter (3 : 4) than femur; the latter (12 : 5) much longer (8 : 3) than the tibia, which bears four teeth (alternately long and short) at the antero-dorsal apical angle; tarsus approximately 4 : 2 : 2 : 2 : 5, the first joint with 2–3 bristles along the dorsal edge. Mid femur (4 : 1) longer (9 : 8) than coxa and trochanter combined, with four longish bristles in a median row anteriorly and 1–2 more, nearer the dorsal edge, apically; posteriorly there are 8–9 bristles, mainly on the apical two-thirds, 4–5 as on the anterior aspect being in a median row, with the others above, towards the dorsal edge. Tibia distinctly longer than femur, narrow (10 : 1) on proximal two-thirds of its length, then rather abruptly expanding to the apex (7 : 1); along the dorsal edge are about 14 bristles (of which five or six on the apical third are longer), and one or two fewer on the ventral edge; additional bristles occur distally on both faces, so that the apical third of the tibia is distinctly bristly. Tarsus longer than the tibia, its first two joints in ratio 11 : 7. Hind coxa externally naked, but with about a dozen short bristles on inner surface—mainly on dorsal half; femur (2 : 1) not much longer (10 : 9) than coxa; tibia (12 : 5) rather broad towards apex. Tarsus with first joint twice the second in length; chaetotaxy of first joint, dorsal 7–8, anterior 12–13, ventral (plantar) 10—all beyond basal third—posterior 8–9 bristles; those on anterior aspect the thinnest; second joint 3–4, 8–9, 5–6, 5; third joint 2, 6, 4, 3. The plantar spines are stout and rise from definite sockets, the plantar edge not being frayed or fimbriated.

Abdomen. Tergites entire. The first (third) tergite bears over 30 minute bristles, and the spiracle is enormous (fig. 1, *f*). Ovipositor barely projecting beyond the apex of the abdomen. The length visible varies, according to pressure and relaxation of the parts, from 0·04–07 mm. in a series of mounted examples. The last sternite is truncated, except for a long, narrow median projection. Stylet (8 : 3).

Length, 1·5–1·9 mm.; alar expanse, 2·8–3·4 mm.

♂.—Head length 0·45 mm.; length of pronotum 0·35 mm.; mesonotum length 0·23 mm., breadth 0·4 mm; metanotum, length 0·175 mm., breadth 0·35 mm.; propodeon, length 0·175 mm., breadth 0·35 mm.

Head (fig. 1, *g*) twice as long as broad anteriorly and about one-third longer than its maximum breadth. The bristles (1, 1) set just above the median lobe of the clypeus are short—half as long as their basal distance apart. Antenna (fig. 1, *h*) with bulla about four-fifths the length of the scape (11 : 6); pedicel (4 : 3) two-thirds of the scape. Funicle (three joints) twice as long as the scape, its first joint triangular in profile; fourth joint shorter (6 : 7) than fifth, but both greater than the pedicel, which is only five-ninths of the fifth.

The propodeon is remarkably broad posteriorly (fig. 1, *g*).

Legs. Fore femur over twice as long as broad and more than two and one-third times the tibia (excluding the apical tooth) in length; tibia longer (10 : 7) than the tarsus and not equal to the greatest breadth of the femur. Mid coxa, femur, tibia, and tarsus subequal—the coxa very slightly the longest; femur very convex dorsally and subangulate at one-third from the apex; apex of tibia with two teeth at upper angle, one laterally and externally and two ventrally. Hind coxa (2 : 1), or with membranous flange (10 : 7), shorter (10 : 11) than femur (4 : 3); tibia (5 : 2) not quite three-quarters the length of the femur and as long as the tarsus, bearing 4–5 teeth apically—counting both sides; tarsus sparsely set with bristles, one (lateral and preapical) on joints 1–4 being longer.

Length, up to about 2 mm.

Type ♀ in the British Museum, one of a series of ♂ ♂ and ♀ ♀ from a fruiting trunk of *Ficus* sp.

BORNEO: Sarawak, vii. 1907 (*J. Hewitt*).

C. hewitti, sp. n., belongs to the group of which *C. striatus*, Mayr, and *C. crassitarsus*, Mayr, may be taken as representatives. It is at once known in the ♀ by the short ovipositor and the terminal segments of the funicle, while the ♂ is equally characterised by the head and propodeon.

Genus **Eupristina,** Saunders.

Eupristina verticillata, sp. nov.

♀.—Head wider than deep (11 : 10); clypeus with a fine median ridge and distinct but not prominent oral lobes, each with one bristle. The antennal grooves, above the toruli, occupy about one-third of the width of the frons. Trophi: mandibles apically bidentate, with about five ventral ridges (fig. 3, *a*), anterior edge much swollen; appendage narrow, with 8–10 ridges (fig. 3, *a*, *a*[1]) of which 2–3 near the articulation are strong, projecting tooth-like at the inner edge; maxillae (fig. 3, *b*) with no free splint. Antenna (fig. 2) just over 0·5 mm. long; pedicel with a number

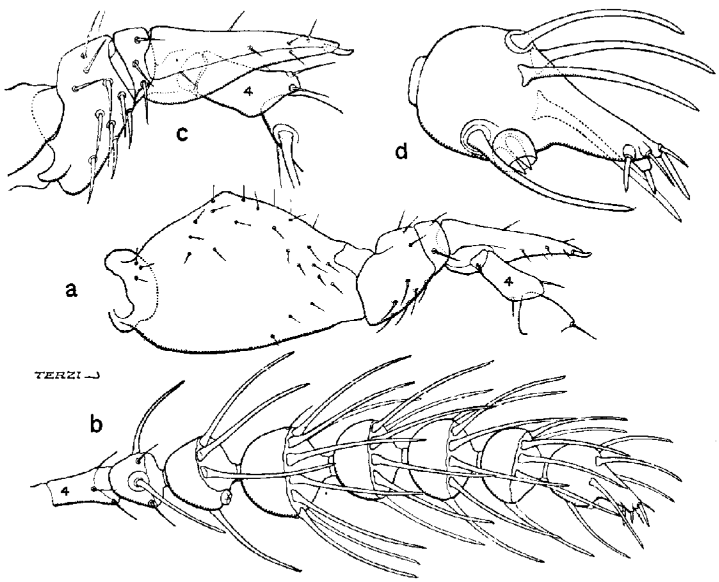


Fig. 2. *Eupristina verticillata*, Waterst., sp. n., ♀ : *a. b*, antenna; *c*, detail of joints 2–4; *d*, apical sense-organs.

of stiff, rather fine, recurved bristles on inner dorsal aspect (fig. 2, *c*); process or appendage of third joint long, completely articulated; sense-organs on joints 5–11 long and tubular, subapical in position; besides these on the outer apical edge of the sixth joint a small cup-shaped sensorium with a short central process (fig. 2, *b*), and another much larger one on the basal half of the eleventh joint (fig. 2 *b*, *d*); at the extreme apex of the club a group of sensory spines—five in all (fig. 2, *d*).

Thorax. Pronotum entire, but with a deep concave membranous area anteriorly; posterior edge gently and evenly concave, the free striate margin expanded abruptly at the extreme sides into a subtriangular head; spiracle not greatly salient. Medianly and anteriorly the sclerite is bare, but at each side posteriorly towards the expansion of the striate margin are 6–7 short bristles in two rows, and about a dozen more round the spiracle. Scutum bare, except for one minute bristle on each side near the furrow at one-third before the suture. Parapsides with six bristles. Scutellum and meso-

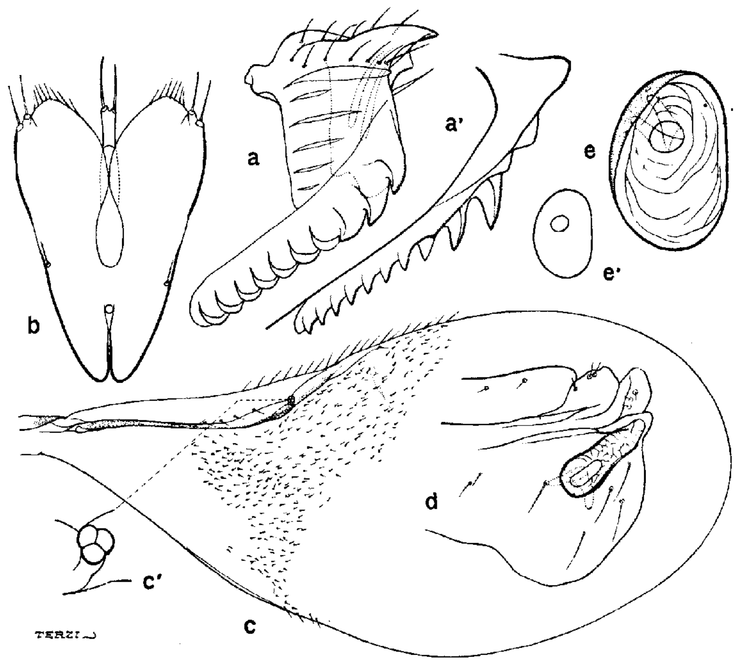


Fig. 3. *Eupristina verticillata*, Waterst., sp. n., ♀: *a*, mandible, ventral view; a^1, mandible in profile; *b*, 1st and 2nd maxillae; *c*, wing; c^1, pustules on submarginal vein; *d*, right half metanotum and propodeon; *e*, abdominal spiracle; e^1, the same, on same scale as *d*.

sternum each with bristles 3–4 : 3–4. Propodeon (fig. 3, *d*) with four moderate bristles beyond the spiracle and one (occasionally two) minute near the posterior end of the spiracle on the inner (admedian) aspect. Metasternum intumescent on each side of the mid line, its surface raised in minute chitinous points.

Forewing (fig. 3, *c*, c^1) just over 1 mm. in length, two and a quarter times as long as broad, bare on about the basal fourth.

Legs. Fore coxa (2 : 1) with a longitudinal row of about 24 long bristles, which form a fringe on inner aspect; femur (17 : 8) about one-third longer than the coxa; tibia over twice as long as broad and equalling in length the breadth of the femur, bearing at the apex antero-dorsally two teeth, with ventrally a short chitinous projection with one spinose bristle above; both anteriorly and posteriorly the tibia bears a lateral row of about four short stiff bristles, and there are a few more along the

dorsal edge; tarsus 2, 1, 1, 1, 3; the first joint bears one dorsal subapical bristle, one anterior, one ventral, and three (stouter) posteriorly; joints 2–5 have bristles 1, 1, 2, 1, while five bears 1, 1, 0, 1. Mid coxa much widened posteriorly; femur (10 : 3) shorter (6 : 7) than tibia (barely 6 : 1), which has about eight short stiff bristles along the dorsal edge and four ventrally on apical third. Tarsus as long as tibia, each joint with one subapical bristle dorsally and another apically and ventrally; joints in ratio, 8, 7 : 7 : 5 : 9. Hind coxa (7 : 4) with 5–7 short heavy spinose bristles; femur (2 : 1) one-seventh longer than the coxa; tibia (3 : 1) three-fourths of the coxa in length; tarsal joints in ratio 15 : 9 : 7 : 6 : 11.

Abdomen. The tergites from the second (fourth) onwards are deeply incised postero-medianly up to about one-half of their length. Between the spiracles is a broadish membranous area, and this tergite is produced anteriorly into a broad, angularly rounded median lobe. The stylet (8 : 5) bears four bristles—three apically and one at the side. The ovipositor sheath is slightly dilated apically, the ovipositor extending beyond the apex of the abdomen a distance of about 0·6 mm. The spiracle (fig. 3, *e*, e^1, same scale as *d*) is oval, flattened on one side.

Length (excluding ovipositor) 1·4 mm.; alar expanse, 2·4 mm.

Type ♀ in the British Museum, one of a small series of ♀♀ " From large tree with small figs in middle of Museum grounds."

BORNEO: Kuching, Sarawak, xi.,1907 (*J. Hewitt*).

E. verticillata, sp. n., is an isolated form which I have placed in this genus with some reluctance. It is easily recognised by its antennae, wings, protergum, etc. The material available for description is in a very broken condition, there being only two complete antennae and one wing in a score of specimens. Such dealation and loss of appendages are commonly incurred when the female enters the fig in which the eggs are to be laid.

The neuration of the single wing preserved is peculiar and perhaps abnormal. There is a distinct marginal and postmarginal length, and in the membrane itself a disconnected pellucid thickening, suggesting an obsolescent radius. Particular attention is for this reason directed to fig. 3, *c*, which illustrates the points referred to.

THE BIONOMICS OF *TABANUS APREPES*, AND OTHER AUSTRALIAN TABANIDAE.

By G. F. Hill, F.E.S.,
Entomologist, Australian Institute of Tropical Medicine, Townsville, Queensland.

(Plates I and II.)

During recent years the number of described species of Australian Tabanidae, or March-flies, as they are almost universally called in this country, has been increased very considerably, and with this increase there has come a wider knowledge of the distribution of the various genera and species. While advancement has taken place in this direction, little progress appears to have been made towards acquiring an accurate knowledge of the life-history and habits of any of these flies, and, up to the present time, no precise information has been published concerning oviposition, larval development, feeding habits and pupation of any of our numerous species.

In this paper I propose to describe in some detail the life-history, habits and developmental stages of *Tabanus aprepes*, Taylor, and *T. rufinotatus*, Bigot, which have been reared from egg to adult, and to discuss other species so far as present knowledge permits.

Tabanus aprepes, Tayl.

T. aprepes, Taylor, Proc. Linn. Soc. N.S.W. xliv, p. 56.

T. batchelori, Taylor, *loc. cit.* p. 58.

Distribution. This species is recorded from South Queensland (Eidsvold), North Queensland (Townsville and Kuranda), and the Northern Territory (Darwin and Batchelor).

Breeding-places. The following notes are based on observations made during the period 18th October 1919 to September 1920, in three localities within the municipal boundaries of Townsville, namely, (1) a small permanent rock-hole and stream arising from it, situated within half a mile of the Institute building, (2) a small shallow swamp about 250 yards distant from the rock-hole, and (3) a group of similar swamps on the outskirts of the town.

During the wet season and for some months afterwards the rock-hole and adjoining pools and riffles (Plates I and II, fig. i.) are completely swept by a rapid torrent of surface and soakage water from adjacent land; but later, when the flow is reduced to a regular and steady trickle, there is present a plentiful supply of algal growth and three or four feet of clear water in the rock-hole and rather less in the pools. From June to December 1919 the moist banks were searched unsuccessfully for larvae and pupae resulting from eggs deposited during the previous summer. On 10th October 1919 and later, Tabanidae were occasionally seen flying about, or momentarily resting upon the heads of children playing on the sea beach distant about 300 yards from the rock-hole—then the only locality within a mile or more from which they could have emerged. The species could not be determined with certainty, but was provisionally referred to *T. aprepes*.

More frequent visits were now paid to the locality in the hope of definitely associating with it the flies occasionally noticed in the vicinity. Digging operations were undertaken wherever the soil was sufficiently moist or loose enough to permit of the emergence of the flies from the ground; then the harder and drier parts of the bank and neighbouring soil were dug over and sifted, the rocks and herbage overhanging the water were searched frequently for ovipositing females or their eggs, and a few

horses and cows which drank at the lower pools were watched, but no evidence of TABANIDAE could be found until 6th January, or two days after the first heavy fall of rain (106 points) since the preceding March.

On 6th January a female *T. aprepes* was observed on a twig about four and a half feet over the water (Plate I), apparently about to oviposit, when she was disturbed by a spider and flew off.

On 13th January three egg-masses were found on the same twig, all of which appeared to have hatched, but on removal to the laboratory three living larvae were rescued from a spider's web which enveloped one end of one mass. Although there appeared to be no unhatched eggs in the masses, the latter were placed over water, and during the night 110 larvae were produced, some of which were subsequently reared to the fly stage and identified as *T. aprepes.*

From 16th January until 16th April numerous larvae of *T. aprepes* were found in the algae floating on the surface of the water. Heavy floods swept the holes in the locality during the month of April, after which larvae were not found.

On 2nd April a female *T. aprepes* was observed to alight on the twig from which eggs were taken on the 13th January, and the process of oviposition was observed, with the aid of a magnifying glass, from commencement to conclusion, when the fly was captured and the eggs removed to the laboratory, where larvae were subsequently reared.

Of the 39 egg-masses collected here (Locality 1) between 13th January and 9th April, five were found on twigs and six on grass leaves or seed-heads overhanging water in the rock-hole (Plate I), the majority being from 3 to 4½ feet above the surface; three were found on grass leaves a few inches above the water trickling from the rock-hole, and 25 on the terminal shoots of couch-grass overhanging a sloping bank (Plate II), the surface of which was oozing with soakage water and algal growth.

The adjacent swamp (Locality 2) dried early in July 1919, and remained in this condition until 4th January 1920. Towards the end of April 1920 the surface area reached its maximum, there being then about 4½ feet of water in the deepest parts. Repeated searches were made for egg-masses on plants overhanging the margin and on lily and other leaves floating on the surface, but none were found. During these searches numerous half-grown to full-grown larvae (*T. aprepes*) were found clinging to the lower surface of the lily leaves, or to the stems, or hidden in floating masses of algae, from 20 to 30 yards from the margin and in from 3½ to 4½ feet of water. A few of these larvae were bred to maturity to confirm identifications.

The small lily-pond (Locality 3, Plate II, fig. 2) dried late in July 1919, and remained so until 4th January 1920. In May of 1919, when the water was two or three feet deep, a careful search was made for Tabanid larvae amongst the reeds and water-lilies, but none were found.

From 10th June 1919 onwards, the banks of this and adjoining ponds were examined from time to time as they dried, but in none of them were the larvae or pupae of *T. aprepes* found, although other species were taken.

From January 9th to April 16th 1920, when the ponds and swamps contained water, egg-masses and larvae were unsuccessfully sought for on many occasions. On the latter date a careful search was made of the vegetation growing near the banks and of the lily leaves in deeper water (4–5 feet) with the result that many larvae of *T. aprepes*, in all stages of development, were captured. On the same date a fly of this species was observed ovipositing (1.45 p.m.) on the underside of a seed capsule of a plant growing in eight inches of water and twelve inches from the bank. When about 30 eggs had been laid, a lamp chimney, closed at one end with mosquito netting, was slipped over fly and plant and tightly plugged with wadding. The stem was then cut off about an inch below the wadding plug, leaving the

fly and eggs practically undisturbed. In this position the chimney and its contents were returned to the water and overhanging plants. Several times during the next hour the fly appeared to be on the point of continuing oviposition, but each time returned to the netting without having extruded any eggs.

Between 21st and 25th April very heavy falls of rain and high winds caused an accumulation of drift (grass, aquatic plants, twigs, cow and horse dung, etc.) to be thrown up on the sloping banks of this and adjacent pools. When examined on 28th April, numerous half-grown to full-grown larvae of *T. aprepes*, *T. rufinotatus* and *T. nigritarsis* were found in the drift and on or under the soil beneath it; while others were found buried in the grass-covered soil between the outer fringe of the drift and the foot of a stiff loamy bank three or four feet from it (Plate II, fig. 2). The latter were full-grown and were in some cases obviously at rest in the positions in which they intended to pass through the long dry period to follow; in others they were still burrowing downward. Quite a number of those found in the drift, and especially in that part near the water's edge, were evidently feeding, as shown by the contents of the alimentary tract. Many of these larvae (*T. aprepes*) were captured and bred out in the laboratory in July and August.

While turning over the soil and drift on this date several recently discarded pupal cases were found and subsequently identified as those of *T. rufinotatus* and *T. nigritarsis*. These pupae were almost certainly the product of eggs laid more than a year earlier, since the unusual conditions of the 1919–20 season and the shortness of the possible breeding period (103 days) almost preclude the possibility of their being derived from eggs laid during the current year. No definite evidence has been obtained to determine the maximum period during which the larvae of these insects may remain in a dormant condition, but certain facts suggest that full-grown larvae may, after the usual long resting period and in the face of a drought, postpone their transformation into pupae for six months or more.

On the same date (28.iv.1920) and a few yards distant, full-grown larvae of *T. aprepes* were found making their way up a slope from the water's edge, through short wet grass and litter towards a bank (similar to that shown in Plate II, fig. 2) and about eight feet from the water's edge. Some were actually travelling when observed, others were sheltering in the grass or under debris.

These banks were examined four months later (30th August), when several *T. aprepes* (three pupae and five larvae) were found, and on the same afternoon an adult female was captured in the vicinity. The period (winter) intervening between these dates, 28th April–30th August, had been unusually mild and moist, doubtless favouring early development and rendering the emergence of the adults possible after even a light shower of rain. During the preceding year, owing to drought conditions, emergence of adult flies from this soil would have been a physical impossibility throughout the whole period April 1919 to January 1920.

Oviposition. In discussing breeding-places brief reference has been made to two flies which were observed in the act of ovipositing on 2nd and 16th April. As the process differed in several respects from that recorded for Indian and American species, it may be of interest to refer to it more fully here. At about 4.30 p.m. on 2nd April, whilst sitting by the water's edge (Locality 1), a fly was seen to alight on the underside of a twig about four feet above the surface of the pool (Plate I) and about three feet from my head. The twig lay at an angle of about 45° to the water, and the fly settled on it *head uppermost*. After lightly touching the surface of the twig many times with the tip of the abdomen, the first egg was extruded whilst only the extreme apex of the abdomen was flexed. Immediately the apex of the egg touched the twig it appeared to stick, and as it left the body it was forced out of the vertical position to an angle of about 20°; the apex of the abdomen was again applied to the twig at the point of attachment and to one side of the egg just laid and a second

extruded in the same manner. Three eggs were then laid close to and in front of the first two, each one as it left the ovipositor being pressed firmly against those behind, until the latter lay almost parallel to the twig. In this way three or four gradually widening rows were laid, each slightly nearer vertical than the preceding one. Then a second and similar tier was commenced on top of those already laid, the first row of eggs of the second tier resting on the second or third row of the lower tier. Moving her body slightly forward, the fly extended the lower tier two or three rows before continuing the upper tier. In this way the operation was continued until the mass had covered the lower side of the twig for a length of 30 mm., when the fly moved forward a few millimetres and remained stationary until captured. The rate of oviposition was about three eggs a minute, and at no time was the apex of the abdomen brought *under the thorax,* as stated by writers dealing with extra-Australian species.

The Egg-mass. The size and shape of the egg-masses are very variable. As a rule they are about 20–33 mm. long by about 2 mm. wide when deposited on slender twigs or narrow blades of grass, or they may be more compact when laid on seed-heads or other objects offering a wider base for the mass. The mass is invariably as wide as the object upon which it rests and generally contains two layers of eggs. Some of the masses, however, contain three layers of eggs and are proportionately shorter and higher. Sometimes a second and even third mass is laid very near to or overlapping part of an earlier one, and small masses containing only a few score of eggs are found near masses of average size. The number of eggs per mass probably averages about 500, but much smaller and much larger masses, *i.e.*, 250–700, are found. At first the mass is creamy, but in the course of about 24 hours it changes to light slate-purple, and gradually darkens with the development of the larvae. There is a complete absence of the white chalky substance used by some species as an outer coating of the mass, and more often than not its general appearance is distinctly rough and lacking finish.

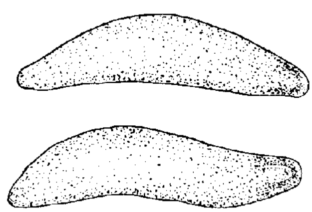


Fig. 1. *Tabanus aprepes*, Tayl., eggs.

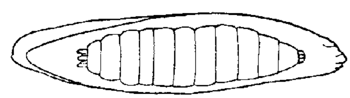


Fig. 2. *T. aprepes*, embryo 78 hours old.

The Egg. The eggs measure 1·60 mm. to 1·65 mm. in length, by 0·3 mm. in width, and are variable in shape according to their position in the mass, but always bluntly rounded at either end (fig. 1). The surface is smooth and glossy and, in recently laid eggs, pearly white. The colour changes rapidly; eggs that were laid at 1.50 p.m. on 16th April changed to grey by 5.15 p.m., to dark slate-purple by 9.30 a.m. on 18th, and hatched during the night of 22nd or early morning of 23rd. Another batch of eggs which was laid at 4.30 p.m. on 2nd April changed to dark slate-purple by 9.30 a.m. on 4th and hatched between 2 and 4 p.m. on 8th. The egg period therefore was from six and a quarter days to seven days in the one case and about six days in the other.

For at least 24 hours before the young larvae hatch they are distinctly visible through the clear, thin shell (fig. 2). During this period they are active, dark-banded little creatures, with the head always directed outwards from the point of attachment

of the egg-mass. When about to liberate themselves the blade-like process (egg-cutter) at the anterior end is pressed against the apex and drawn downwards along the side in two or three deliberate strokes, which cause a rent in the shell sufficiently large to permit the young larva to escape rapidly.

Larval Development. Generally speaking, there is only an interval of a few minutes between the appearance of the first and last larvae from a given batch of eggs. Sometimes, however, the interval is much longer, and this is especially the case with large masses, in which, owing to their form, many of the eggs are concealed beneath tiers of other eggs. One large mass from which all the larvae had apparently emerged before noon (13th January) produced 110 additional larvae before 9 a.m. on the following morning; another produced about 600 larvae during the morning and 30 more late in the afternoon.

In only one instance (5th April) was the dispersal of larvae observed under natural conditions. On this occasion several very small larvae were gathered on the surface of the pool (Plate I) in one dip of the scoop while searching for *Anopheles*, and upon examining some twigs overhead an egg-mass was found from which larvae were then dropping. The mass contained approximately 300 eggs, arranged in a single layer eight or ten abreast, of which number about one-third had already hatched and dropped into the water; the balance emerged during the succeeding five or six minutes. Upon reaching the water the young larvae were rather sluggish, but sufficiently active to disperse by slow lashing movements, some remaining on the surface film, others seeking the shelter of floating masses of algae. Some of these larvae were collected and removed to the laboratory for examination and observation.

In the laboratory the egg-masses were usually suspended over a shallow dish of clean water, into which the young larvae dropped as they freed themselves from the mass. For some hours they remained more or less quiescent on the surface, during which period the first moult was accomplished. This process commences before, or immediately after, the young larvae leave the egg, and is sufficiently advanced to be seen under a low power five minutes later. Apparently the first moult is always completed during the first six hours of larval life. As a number of larvae from one egg-mass have been reared through all their stages to the perfect fly, the development of these may be now recorded. While this batch was under observation a number of other batches were available for study, and they supplied much information and material for examination which could not have been obtained from the constantly decreasing ranks of the original batch.

The egg-mass from which the larvae were obtained was found partly evacuated on 13th January (Locality 1); 110 young larvae emerged from it on the afternoon and night of 13th–14th January and 105 of these comprised the original batch.

First Instar. An accurate description of the young larva soon after it emerges from the egg is somewhat difficult, owing to the fact that ecdysis has already commenced. When about five minutes old and after fixation in the usual way the young larva measures about 1·40 mm. long by 0·28 mm. wide at the sixth segment; the segments appear to be withdrawn into each other; the cuticle about to be cast off envelopes the body loosely, excepting at the head, where it is firmly attached. The surface is pale in colour and distinctly marked with longitudinal striae; several moderately long slender hairs are present about the middle of each segment; there are no short spine-like hairs fringing the anterior margin of the first three segments (thoracic), such as occur on the fourth segment and in increasing numbers on the fifth to the tenth segments. The anterior margin of the first two segments and the anterior and posterior margins of the following seven segments appear to be banded, but this appearance is due to characters on the cuticle beneath. The mandibles are withdrawn into the head, but in cleared specimens they are seen to be short, curved rods arising apparently in the anterior third of the first segment. The egg-breaker

is a black, chitinous, angular projection of the upper anterior margin of the labrum and is the most conspicuous feature of the first instar. Graber's organ is visible on the posterior portion of the tenth segment as a pair of dark, pyriform, closely approximated bodies.

Second Instar. Since most of the characters found in the larvae of the second instar are visible through the cuticle of, and appear to belong to, the first instar, the changes which follow the first ecdysis do not appear to be so great as they are in reality. Fixation in hot alcohol after the first ecdysis is completed and in all subsequent stages of larval development has the usual effect of extending the body to its fullest length; thus, whereas the length of a larva of the first instar is about 1·40 mm., the length just after moulting is about 1·00 mm. greater. The measurements, descriptions and figures which follow are all from specimens fixed in hot 70 per cent. alcohol, and therefore fully extended. The characters of the larvae of the second instar are shown in fig. 3, which represents a larva between one and six hours old. Such larvae range

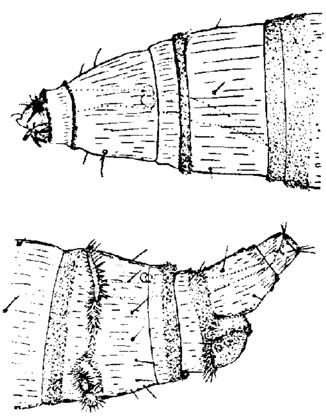


Fig. 3. *T. aprepes*, anterior end of larva 1–6 hours old (above); posterior end of same (below).

from 2·35 mm. to 2·63 mm. in length, by 0·375 mm. to 0·425 mm. in width at the widest part; the segments bear distinct longitudinal striae; the anterior border of each segment, excepting the first three (thoracic), is fringed with numerous small bristle-like hairs and dense short brown pile, which produce the banded effect (segments four to nine inclusive resemble the tenth segment shown in fig. 3). The first three (thoracic) segments are shown in fig. 3. The mouth-parts are prominent; the first maxillae, palpi, and antennae are easily distinguished; the anterior projection of the labrum is rounded and no longer black and chitinous; four malpighian tubes are distinguishable; Graber's organ still contains one pair of bodies, which are now seen to be enclosed in a pyriform sac, the rounded end of which is foremost; the apical third of the syphon tube bears two groups of three long slender hairs, which usually appear to arise at the extremity owing to invagination of the apex and withdrawal of the stigmal plate.

During the 16 or 17 hours following the first ecdysis there is little apparent change in the young larva other than a slight increase in size and, generally, the addition of another pair of bodies in Graber's organ. A long series of larvae of this age measured from 2·35 mm. to 2·82 mm. in length, by 0·35 mm. to 0·425 mm. at the widest part.

For about three days following their emergence the young larvae do not feed, but remain on the surface film. After this period, however, they commence to attack each other, even in the presence of an abundant supply of small shells and other animal life introduced upon aquatic plants.

When twelve to fourteen days old the majority of the larvae measured from 6 mm. to 7 mm. in length, by 0·7 mm. to 0·85 mm. in width; the groups of hairs on the syphon tube increased to four or five, and Graber's organ contained either two or three pairs of bodies, each pair diminishing in size from the anterior end. A few of the larvae had developed very slowly during these twelve days and now measured only 4·5 mm. in length. In two larvae (7 mm. and 8·5 mm. in length respectively) a second pair of mandibles could be distinguished in the anterior third of the first segment, and faint traces of the dark bands characteristic of older larvae of this species could be detected near the junction of the segments and near the anal protuberance. The second ecdysis apparently takes place when the larva is between 7 mm. and 9 mm. in length. Unfortunately the number of larvae in this batch became so reduced, largely owing to cannibal practices, that specimens could not be secured as frequently as desired to determine this point, but a "wild" larva captured on 2nd March appeared to represent an early stage of the third instar and to connect the last-described individuals with older and more advanced ones of the same batch. This larva measured 9 mm. in length by 1·5 mm. at the widest part; the junctions of the segments were banded and blotched with dark brown, and the dorsal tubercles and the pseudopods bore short bristle-like hairs, as in older larvae.

On 2nd March, or when 49 days old, two larvae of the original batch measured 15 mm. and 16 mm. in length respectively. Whether the subsequent changes in the larvae follow ecdyses, or whether they are developed gradually during the third instar, has not yet been satisfactorily determined. On 16th April, or when 94 days old, two other larvae of this batch were destroyed by their fellows. The former now measured 21·5 and 24 mm. long by 3 and 4 mm. wide respectively. The brown bands and blotches are now very distinct and of the same pattern as in adult larvae; the striae are well marked on all segments, but are absent on the brown areas; the mandibles are black; the bunches of stout curved spines above the insertion of the antennae are pale ferruginous, very prominent, and overhang what appear to be moderately large facetted eyes situated behind them; in the smaller of the two larvae there are five pair of bodies in Graber's organ, in the larger six pairs; the stigmal plate is now visible at the apex of the syphon tube. About the anterior third of the first segment (prothoracic) there are several long branched hairs, on other segments they are simple or absent; the pseudopods are prominent; there are no hairs on the anterior margin of the thoracic segments, these being confined to the dorsal ridges and pseudopods of the abdominal segments, where they are inconspicuous. The dark bands and blotches are formed entirely of very short and dense pile, as in the younger larvae; the pseudopods were very prominent in the larger of the two larvae.

On the same date (16th April) the contents of the breeding-tray were collected, with the object of separating the remaining larvae of *T. aprepes* and several larvae of *T. nigritarsis* which had been placed in the tray recently. The former now numbered only five, two of which measured about 28 mm. long and three about 33 mm. long. One of the latter was retained for examination and is described below, the others were put separately into five-inch flower-pots half full of moist, clean granite sand, upon which lily leaves and shells were placed every three or four days. The larva referred to above was 94 days old at the time of its death, and measured 33 mm. in length and 5 mm. in width. In size and coloration, as well as in external form, it so closely resembles the mature larva which has undergone a long resting period that a description of it will suffice for both. There are six prominent pseudopods to each segment from the fourth to the tenth inclusive, arranged on the anterior margin, three on each side of the median line; each pseudopod is armed with a number of short bristle-like hairs; on the dorsal surface of the same segments there are two transverse

tubercles situated on the anterior margin on either side of the median line, which appear to be of the same nature as the pseudopods and similarly armed. The dorsal surface is blotched and banded boldly with dark brown (fig. 5), the pattern of which is very characteristic and constant. The ventral surface of segments four to nine inclusive are creamy white; from the dark anterior margin of the first segment

Fig. 4. *T. aprepes*, adult larva, lateral view.

Fig. 5. *T. aprepes*, adult larva, dorsal view.

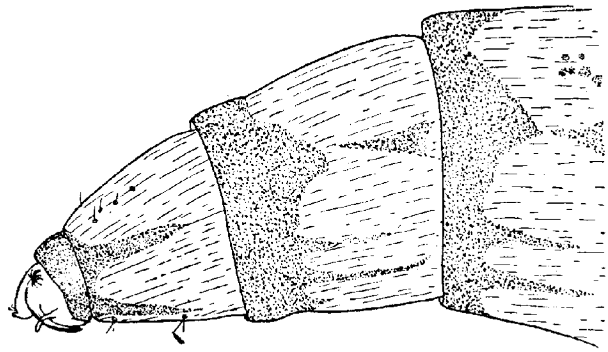


Fig. 6. *T. aprepes*, adult larva, anterior end.

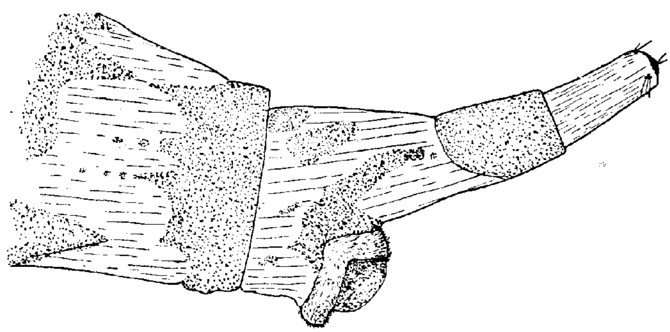


Fig. 7. *T. aprepes*, adult larva, posterior end.

(prothoracic) there extend posteriorly five dark, lanceolate marks, one on either side of the dorsal and ventral surfaces, and one in the median line of the ventral surface. The second and third segments are banded anteriorly (fig. 6) and the tenth posteriorly (fig. 7) with brown.

As the larvae reached maturity and ceased to feed (about the third week in April) they were placed together again in a large receptacle containing moist sand, in which they remained for about two months. At first they were very active, coming to the surface at night and returning to the sand during the day, but never attacking each other. On 3rd June they were all in a torpid state and contracted to about 18 mm. in length, but when placed in water they regained their normal appearance and activity.

On 25th June one of the larvae, now 164 days old, pupated in a vertical position four inches below the surface and after a pupal period of 11 days emerged as a perfect fly (female). Another larva pupated about a week later and was preserved as a specimen; the third pupated on the 7th July and produced a male fly on 21st July, or 190 days after hatching; the fourth remained in the larval stage until 8th September (239 days), when it was destroyed for examination.

Larval Habits under Natural Conditions. Under natural conditions the larvae are to be found commonly on or near the surface of clear and moderately deep pools, amongst submerged herbage near the banks, resting upon the lower surface of lily leaves, upon the submerged stems and leaves of all kinds of aquatic plants and in floating masses of algae. Clear and moderately deep water appears to be essential. The food of the young larvae is not known, but it is believed to be the small molluscs, which were fed successfully to larvae reared in captivity. Several kinds of molluscs are very plentiful in most of the breeding-places, and these certainly form an important part of the diet of older larvae, which have frequently been found feeding on them.

In the rock-hole (Locality 1) this food is absent, but there is a plentiful supply of other kinds. Cannibalism is common amongst "wild" larvae, and is practised by individuals in all stages of development. To give some idea of the voracy of these insects, it may be mentioned that on one occasion 12 large larvae were placed in a pickle-jar of water and algae for transportation to the laboratory—a journey of three miles—and upon arrival there only two remained alive, one of which destroyed the other before arrangements could be made for their separate accommodation. On another occasion over 50 nearly full-grown larvae were placed in a large porcelain dish with sand, water and fresh molluscs. Within four days many of the latter and 40 of the larvae were destroyed.

With the aid of a small stout wire net attached to the end of a long bamboo rod the plant growth can be disturbed sufficiently to dislodge the larvae, which, even if carried down by the currents thus created, soon appear near the surface and are easily captured in the net. In some cases a stout wire hook at the other end of the rod was found useful for dragging masses of vegetation towards the bank for closer inspection. Wading was resorted to in many cases, but the results were usually unsatisfactory on account of the restricted range of vision.

The larvae appear to live entirely in water until they have reached maturity, when they migrate from the water to high ground close by, as described elsewhere in this paper, and penetrate into the soil or clay to a depth of from 7–15 cm., where they remain in the larval stage, generally with head uppermost, for several months.

The Pupa. During the first few hours following metamorphosis the entire pupa is buckthorn-brown,* but the eyes soon deepen to mummy-brown, and then to blackish brown, while the thorax becomes argus-brown. The average size is about 21 mm. in length by 4 mm. in width at the thorax, the 1st and 6th segments slightly narrower than the 2nd to 5th inclusive.

On the dorsal surface of the first abdominal segment there are two stout hairs on either side of the median line and three on each pleura, two of which arise close together near the wing-sheaths. Segments 2 to 7, inclusive of both surfaces, bear an

* Ridgway's colour nomenclature.

uninterrupted fringe of long and short bristles arranged roughly in two rows, the shorter bristles nearer the base; on each segment from the 2nd to 5th these bristles increase in length; on the 5th, 6th and 7th they are equally long or, rarely, the long bristles may be absent from the middle of the seventh tergite and sternite and the shorter ones may be branched.

The six projecting spurs at the apex of the abdomen are arranged three on each lobe of a prominent bilobed tubercle divided vertically by a deep cleft, which is wider in the males; the upper and middle pair are equally long and stout, the lower are smaller; on either side of the dorsal surface midway between the base of the tubercle and the apex of the 7th segment there is a group of four or five stout spines of unequal length. The length and stoutness of these bristles vary greatly in individuals of either sex.

The anal tubercle is very large and deeply furrowed in the male and is bordered anteriorly by an unbroken fringe of about 18 to 22 stout bristles of variable lengths. In the female the fringe is broadly interrupted in the middle, and consists of from 6–9 bristles on either side (fig. 8).

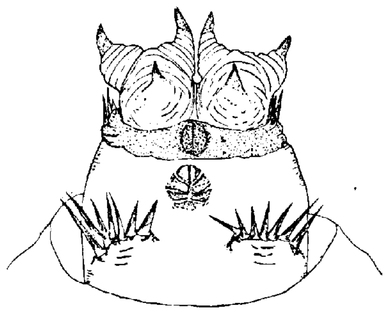


Fig. 8. *T. aprepes*, ventral surface of last segment of female pupa.

Duration of the Pupal Stage. The duration of the pupal period during the months June–September varied from 8 to 20 days, the average being 12 days in the case of 10 individuals whose periods were accurately observed.

The factors which determine early or late emergence of laboratory specimens are not known, and no explanation can be offered at present of the fact that whilst certain pupae of a batch pass through a very short pupal stage—*e.g.*, eight days—others of the same batch and subjected to the same treatment may remain in the stage for periods up to 20 days.

Emergence of the Fly. The emergence of laboratory-bred flies has been observed on several occasions—always between 10 a.m. and 4.30 p.m.—and in each the procedure was similar. The pupa, with its body vertical, works its way to the surface, from which it protrudes the thorax and first two or three abdominal segments. In this position it remains motionless for from one to two hours; then, with very little apparent effort, the thorax is burst on the dorsal surface to the posterior margin of the mesothorax, and also along the lower margin of the eyes, leaving a flap-like piece bearing the anterior group of tubercles more or less loosely attached ventrally. The fly frees itself in a minute or two, leaving the greater part of the pupal case as before. At emergence the wings are uniformly opaque, but in the course of an hour or two they become hyaline or suffused with brown, as the case may be.

The Adult. The adults of this species show considerable variation in regard to size and coloration and, as might be expected, in laboratory-bred specimens this is more

apparent than in those bred under natural conditions. In a recent paper* it has been stated that the wings show various gradations in colour from a total absence of infuscation to a very pronounced shading, especially at the veins. A long series of males and females bred out in this laboratory show these gradations to a marked degree, not only in flies reared from full-grown larvae captured in natural surroundings, but also in flies reared from the same batch of eggs. Variations in abdominal coloration of both sexes, and especially in the females, is even more pronounced. In some specimens there are evident spots at the apex of certain segments, in others the abdomen is of uniform dark brown or uniform ochraceous tawny. In three wild females captured in June in this district the colour of the abdomen is so light as to lead the writers of the above-mentioned paper to refer them with some doubt to this species. Recently, however, a similar form has been bred from a batch of eggs which also produced individuals showing all the variations of wing and abdominal coloration. It would appear that in this and other species too much attention has been paid in the past to slight or even marked differences of this kind. When these variations in colour are associated with abrasions of the abdomen and thorax, and especially of the front, the possibilities of error in diagnosis are greatly increased unless a fairly long series is available for comparison.

In life the lower third and the lateral and posterior margin of the eyes of the male are claret-brown with emerald-green iridescence; the upper two-thirds are drab grey and composed of coarse facets. In the female the facets are small throughout and the colour uniform drab grey with brown iridescence.

Seasonal Occurrence. Throughout Australia, perhaps excepting the wet belts of the North Queensland coast, of which I have little knowledge, there is a marked seasonal occurrence of flies of this family, namely from about October to April. In the southern regions, where there are regular winter rains and low winter temperatures, the emergence of flies is probably regulated by temperature and not by rainfall; but in the north, where the temperature is more or less equable and the rainfall is, excepting for moderate falls, confined to the summer months above mentioned, the condition of the soil, whether dry or wet, is most certainly the regulating factor. Thus almost invariably the march-fly season is either early or late, good or bad (from the collector's point of view) according to whether the summer rain is early or late and normally heavy, light or absent.

The chief natural breeding-places in this district, and in most others with which I am familiar, are in temporary accumulations of water, such as shallow swamps, which disappear completely in the winter or dry season and after the full-grown larvae have entered the soil in the vicinity of the water's edge, wherever that may be at the time of their reaching maturity. As the soil dries these larvae are practically immobilised, and remain so until it again becomes thoroughly moistened. It follows, then, that there can be no emergence of flies until after heavy rain has fallen.

The truth of these statements has been demonstrated on many occasions, and notably during the summer of 1919–20, when until 4th January the country was in the grip of a severe drought, and there was an almost complete absence of Tabanids in this district. Heavy rains for a short period in this month were followed by the appearance of a moderate infestation of flies. (It may be stated here that the previous season also was one of unusually low rainfall, and therefore an unfavourable one for fly breeding.) The January rainfall was not sufficiently heavy to raise the level of the swamps to normal, and another long spell of dry weather intervened before the banks in the vicinity of the normal high-water marks were thoroughly saturated. About the middle of April abundant rains filled the swamps, and there followed a marked increase in the number of flies in the district. Whether the flies were derived from eggs laid in January 1920 or during the preceding wet season could not be

* Ferguson & Hill, in the press (Proc. Linn. Soc. N.S. Wales).

determined, but the period required for the life-cycle, as ascertained later, suggests strongly that the latter was more probable. Further, there is no evidence to suggest that the Tabanids in this or other districts known to me produce two generations in one season. Obviously these remarks do not apply to localities in which there is permanent surface water, such as Locality No. 1.

In some localities a few individuals of certain species, particularly *T. rufinotatus*, are to be found throughout the dry season (June to August), but their occurrence can be accounted for by the presence of permanent water (such as Locality No. 1), or at any rate marshland, in the vicinity.

During June of this year numerous young larvae were found in pools which dried a few weeks later. The question naturally arises whether these larvae perish or whether they are able to burrow into the mud to lie dormant through the remainder of the dry season and until conditions again become favourable for their development. Attempts to determine these questions have been unsuccessful, but it may be mentioned that one larva from a late batch of eggs was, when about 9 mm. long, accidentally isolated in the laboratory in a pot of dry sand and without food of any kind from about 6th June to 28th August. On the latter date it had the general appearance of adult larvae in the resting stage preceding pupation, and became active immediately it was placed in water containing suitable food and cover. Unfortunately neglect caused its death before any development could be detected. Hine, working in America, found that certain Tabanid larvae after a long resting period again fed before pupating, but nothing of the kind has been observed to take place in the case of any of the species studied here.

Rearing Larvae in Captivity. Various methods of rearing the young larvae were tried, but as none of them gave satisfactory results it is not intended to describe them in detail. In order to prevent cannibalism young larvae were isolated in small earthenware pots with a capacity of about 120 c.c., prepared in various ways, and supplied with various kinds of food. Apart from the difficulty of keeping the water in these vessels fresh, this method was found to be too cumbersome, and the larvae rarely survived for more than a week or so. Larger vessels, *i.e.*, five-inch flower-pots and small museum jars, were equally unsatisfactory. Kerosene tins cut lengthwise into two equal parts gave better results, and in them a few larvae were reared from the egg to maturity. These tins were prepared by placing a quantity of clean sand at one end and two or three inches of water at the other. Pieces of water-lily leaves, algae and swamp plants carrying small molluscs were placed in the water to afford shelter and food, and these were renewed as often as possible. The water was changed every four or five days by lifting one end of the tin and allowing it to filter through the sand. The tin was then partly filled and again emptied in this way, before being finally replenished with water and food-bearing vegetation. Each tin contained the progeny from one batch of eggs, *i.e.*, 300–600 larvae, of which never more than 1–2 per cent. reached the imago stage. When molluscs were not obtainable mosquito larvae and small earthworms were offered as substitutes, but worms were invariably refused by larvae in all stages of their development. Mosquito larvae were destroyed by the Tabanids when the former were stranded in algae or sand, but otherwise they appeared to have been able to avoid capture. At all times Tabanids of this species appear to feed upon their fellows in preference to molluscs or any other animals, and for this reason it was found best to transfer the survivors, when nearly full size, to separate pots or dishes, where they completed the development in moist sand, upon which molluscs and portions of lily leaves were placed. The best results were obtained from a batch of 105 larvae which were reared in a concrete trough, measuring 16 inches wide by 20 inches long by 6 inches deep, prepared similarly to the tins just referred to. As the larvae approached maturity the water was gradually reduced until it was confined to a small area at one end of the trough. In this molluscs were placed every week or so, until

it was found that none were being devoured, when the water was drawn off and the trough half filled with clean sand, which was kept moist. From time to time the sand was turned over to watch the progress of development, but beyond this the larva received no attention for intervals of several weeks. Some of the larvae pupated and produced flies in this trough, but most of them were transferred to small pots of clean moist sand, where they completed their development. In future it is intended to use these large troughs or galvanized iron trays instead of the smaller vessels.

Tabanus rufinotatus, Big.

T. rufinotatus, Bigot, Mem. Soc. Zool. France, v, 1892, p. 673.

T. lineatus, Taylor, Rept. Aust. Instit. Trop. Med. 1911, p. 65.

T. elesteem, Summers, Ann. Mag. Nat. Hist. (8) x, 1892, p. 224.

T. designatus, Ricardo, Res. Expéd. Sci. Néerlandaise Nouv. Guinée, ix, pt. 3, 1913, p. 390.

Distribution. This is a widely distributed species, having been recorded from South Australia, New South Wales, Queensland and the Northern Territory, and also from Dutch New Guinea. The South Australian specimens in the British Museum collection are most probably from Port Darwin (Northern Territory) or its vicinity, which prior to 1911 formed part of the state of South Australia.

Breeding-places. On 25th March 1919, an egg-mass was taken from the lower surface of a *Juncea* leaf growing three feet from the bank of a shallow water-hole (near Locality 3) in twelve inches of water. At the time the pool contained a maximum depth of three feet of water and was much frequented by cattle and horses which grazed in the district. As the season advanced the water dried back rapidly and finally disappeared before the end of May. During the period intervening between 25th March and 28th May 1919 the vegetation near the water and the muddy banks and bottom were searched for egg-masses and larvae respectively, but without success. During the same period and up to the present date (September 1920) many other possible breeding-places have been repeatedly examined, but so far only a few adult larvae have been secured.

The Egg-mass. The egg-mass referred to above, from which the larvae described in the following notes were derived, measured 5·5 mm. in length by 4·25 mm. in width at the base and 3·5 mm. in height. The eggs, which numbered about 500, were arranged very compactly in three tiers and were coated, either separately or collectively, with a white secretion. After the larvae hatched, the mass retained its form so perfectly that, viewed from any direction but from above, it appeared to be still composed of viable eggs.

Larval Development. The larvae hatched almost simultaneously at noon on 30th March and moulted between that hour and 9 a.m. on the following day. Specimens were not secured prior to ecdysis, so that the first instar cannot be described here.

The Second Instar (figs. 9, 10). When 24 hours old the larvae of the second instar measured from 2·5 mm. to 2·6 mm. in length by about 0·25 mm. in width at the widest part. Up to this age they were of uniform size, but at the end of the second day variations became apparent, some measuring 3 mm., while others had increased to 3·5 mm. The cuticle is creamy white and bears minute longitudinal striae; the tufts at the base of the antennae are short and many of the component hairs are forked; the prothoracic segment is short, and the hairs which fringe its anterior margin and the anterior margin of the next segment are difficult to discern. The dorsal tubercles and pseudopods are armed with moderately large hairs, and each segment bears several isolated long, slender, pale hairs.

The young larvae remained in a small dish of water for three days without food, when they were placed in a large concrete trough containing sand at one end and

water at the other. In this they were offered small molluscs, young mosquito larvae and small aquatic animals that adhered to the water-lily leaves used to provide cover. From time to time dead larvae were found which appeared to have been destroyed by their fellows, but the remainder seemed to thrive. On 10th June, or when 77 days old, one of the larvae measured 15 mm. in length. Unfortunately this specimen was lost before a detailed description was obtained. On 3rd July the sand was allowed to dry off gradually, and from this date onwards small earthworms only were offered as food. On 8th October the sand was washed over, but no larvae were found. The vessel and its contents were left undisturbed until 27th October, when the now dry sand was sifted, yielding three larvae measuring from 22 mm. to 23 mm. in length by about 2·5 mm. in width. In such larvae the cuticle is glossy and devoid of the striae observed in larvae of the second instar, there is no trace of banding, and the hairs on the dorsal tubercles and pseudopods are colourless.

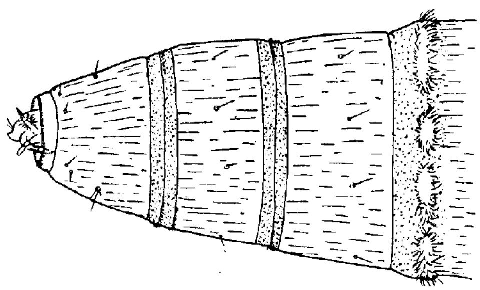


Fig. 9. *Tabanus rufinotatus*, Big., anterior end of larva 24–48 hours old.

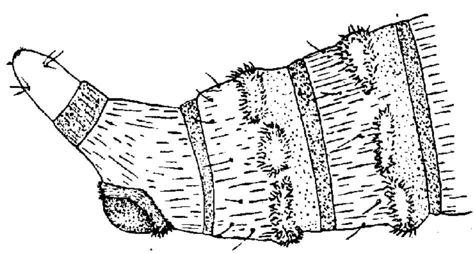


Fig. 10. *T. rufinotatus*, posterior end of larva 24–48 hours old.

The two remaining larvae were now placed in a large shallow dish, containing sand at one end and water at the other, in which they were fed on earthworms and mosquito larvae until 8th November, when they were placed separately in five-inch flower-pots standing in a dish of water and containing three inches of clean sand. On 8th December both larvae were evidently fully grown. One of these was secured for examination and is described below, the other was returned to its pot, to which had been added a few small earthworms and a little earth. A week later it was found dead and damaged beyond recognition by scores of nematode worms. The loss of the sole surviving larva rendered the identification of the species with which I had been dealing for over nine months impossible for the time being, but the larvae secured on 27th October

and 8th December provided the material from which a determination was subsequently made in comparison with a series of "wild" larvae, some of which were subsequently bred out.

The Adult Larva (figs. 11, 12). The full-grown larvae measure from 26 to 29 mm. in length by about 4 mm. in width, and are creamy white in colour, with the faintest indication of darker bands; the cuticle is glabrous and without striae; the tufts at the base of the antennae are composed of short stout hairs; there are no hairs on the anterior margin of the thoracic segments, and those of the dorsal tubercles and pseudopods are very short, slender and dark in colour.

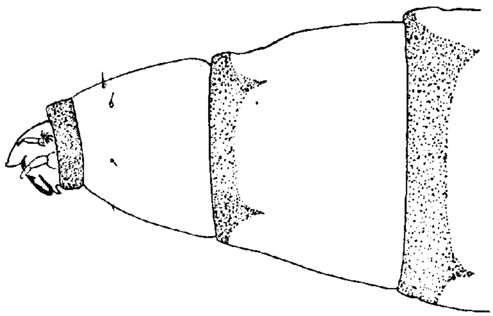


Fig. 11. *T. rufinotatus*, anterior end of adult larva.

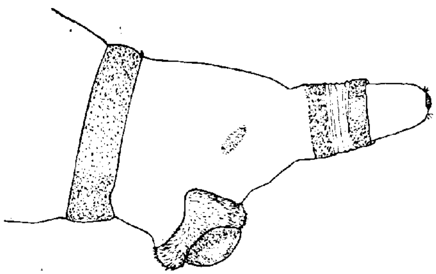


Fig. 12. *T. rufinotatus*, posterior end of adult larva.

From this record it will be seen that under laboratory conditions the larval stage was not less than eight and a half months.

Development of Larvae under Natural Conditions. Larvae were taken on 28th April 1920 in association with the larvae of *T. aprepes* and *T. nigritarsis* (see notes on *T. aprepes*), and again in a similar bank on 15th June in association with the larvae of *Silvius notatus*. After securing specimens for examination, the remainder were placed in small earthenware vessels containing sand, which were thereafter kept moist. The flies emerged as follows:—one female on 23rd May (after a pupal period of nine days), one male on 2nd June, and one female on 21st July.

The Pupa. The average length of the pupa is about 15 mm. and the width at the thorax about 4 mm. The eyes are blackish; the vertex (in the female) and thorax Dresden brown, the latter with faint traces of stripes; abdomen ochraceous tawny, with Dresden brown stripes corresponding to the black stripes on the abdomen of the

imago. The first abdominal segment bears two isolated hairs on either side of the median line and one on each pleura behind the spiracle; the second to seventh tergites and pleurites each have a double row of bristles, those of the anterior row being much shorter than those of the posterior. On the ventral surface, segments 2, 3 and 4 each bear an irregular single row of bristles of varying length; on the 5th to 7th segments the bristles are arranged in two rows; the terminal segment bears the usual number of large spurs (six); anterior to the anal tubercle there is, in the male, a fringe of about twenty long straight or curved bristles, which in the female is interrupted in the middle and is composed of five to eight stout and generally straight bristles (fig. 13). In the male the anal tubercle is large and deeply ribbed, in the female it is small but prominent. On either side of the dorsal surface, midway between the base of the upper pair of spurs and the posterior margin of the 7th segment, there is a group of six or eight stout bristles of irregular size and shape, which in the female is reduced to two or three much smaller bristles; in addition, in the male, there is on either side a group of two or three very short bristles midway between the above and the posterior extremity of the anterior fringe.

Fig. 13. *T. rufinotatus*, ventral surface of last segment of female pupa.

The Adult. In life the eyes of the male have the upper part grey, with deep brown iridescence, and the lower part, lateral and hind margins maroon, with an emerald-green band in line with the insertion of the antennae. The facets of the lower part are larger than those of the upper. In the female the eyes are maroon to dark maroon-purple, with two broad green bands in line with the callus and subcallus respectively.

Seasonal Occurrence. These flies were very scarce indeed during the period February 1919 to September 1920. Females were seen or captured in the field in the months of January, February, April, June, September and December, generally while buzzing about one's head or resting upon one's hat. Horses (locally and in the Northern Territory) appear to be more troubled than cattle, the former usually being bitten about the nose, ears, rump and coronet.

Tabanus nigritarsis, Tayl.

T. nigritarsis, Taylor, Rept. Aust. Instit. Trop. Med. 1911, p. 67.

Distribution. This species has been recorded previously from North Queensland (Houghton River) and the Northern Territory (Darwin, Stapleton, etc.).

Breeding-places and Habits. Between the 19th May and 10th June 1919 five apparently full-grown larvae were gathered from the submerged stems or leaves of

various plants growing in a few feet of water at the margin of a small swamp (Locality No. 3, Plate II) and removed to a concrete trough containing a pile of sand at one end and water at the other. In this vessel they were fed upon molluscs until 3rd July, after which date food was refused by them. The water was now drained off and the sand allowed to dry gradually until only the bottom two inches remained moist, in which condition it was kept for about four months. On 19th August one of the larvae was found in a vertical position about three inches below the surface of the sand. The body was then much contracted, but when placed on the surface the insect became more or less active and extended its length to about 25 mm. This specimen was allowed to bury itself again, and remained undisturbed in the sand until 8th October, when it and two other larvae were found in the above condition. One of these was preserved in the usual way and is described in these notes; the others were placed separately in five-inch flower-pots full of sand and imbedded in the sand contained in the larger vessel, where the two remaining larvae of the original batch of five were presumed to be resting. The two larvae in pots remained very active, but refused to eat either molluscs or earthworms, although they came to the surface almost nightly until 18th November. On 26th November one of these larvae was found undergoing metamorphosis, the other following on the morning of 1st December (11 a.m.), the former producing a female fly on 12th December and the latter a male on 17th December (between 9 and 10 a.m.).

On 27th November the sand in the large trough was sifted and another larva secured, which pupated on 12th December (5 p.m.) and produced a female fly on 28th December. The fifth larva was not recovered and was, therefore, presumed to have been destroyed by its fellows during the early days of their captivity. From the foregoing it will be seen that the pupal period in the laboratory was 16–17 days. Throughout the greater part of their lives in captivity these larvae and pupae showed much restlessness, and in the latter days of their pupal existence frequently wriggled to the surface or projected the posterior end above it, proceedings which would have been impossible under natural conditions owing to the hardness of the soil in which they would have been embedded.

As previously noted (under *T. aprepes*) a few larvae of this species were found in the resting stage in a clayey bank in this locality on 25th April 1920, associated with *T. aprepes* and *T. rufinotatus*. On 15th June following five additional specimens of *T. nigritarsis* were taken under similar conditions in the same locality. At the time of writing (30th September 1920) the majority of these are still in the larval stage in moist sand, others which at the time of capture were embedded in balls or tubes of plastic clay and placed on the laboratory shelves to dry were equally healthy and active when released on 30th September.

The Larva. The adult larva measures about 35 mm. in length by 5·5 mm. in width and is cream-coloured, faintly blotched and banded with yellow ochre (figs. 14–17). The pseudopods are arranged two on either side of the median line on the ventral surface and one on each pleura, these and the dorsal tubercles being only slightly elevated. The surface of the cuticle is dull and distinctly marked with longitudinal striae, except where banded or blotched.

The Pupa. The pupa measures about 23 mm. in length by 4 mm. across the thorax and 5 mm. across the abdomen at the widest part. The eyes are blackish brown, the thorax slightly lighter and the abdomen argus-brown. The first abdominal segment bears two slender hairs on either side of the median line, one on each pleuron behind the spiracle, and two closely approximated hairs on the ventral surface near the margin of the wing-sheaths. On the dorsal surface of the 2nd segment there is a double row of bristles, the anterior row short, stout and of irregular size, the posterior much longer; the 3rd segment is similar to the 2nd; on the 4th, 5th and 6th the bristles increase in size gradually from the 4th posteriorly; on the 7th there are fewer long bristles in the posterior row, their place being occupied by others of intermediate size.

On the pleurae the armature is similar to that of the dorsum, except on the 7th segment, which resembles the ventral surface. On the ventral surface the 1st, 2nd and 3rd segments bear a single row of mixed short and long bristles increasing in length from the 2nd; the 5th and 6th segments resemble the corresponding segments of the

Fig. 14. *Tabanus nigritarsis*, Tayl., adult larva, lateral view.

Fig. 15. *T. nigritarsis*, adult larva, dorsal view.

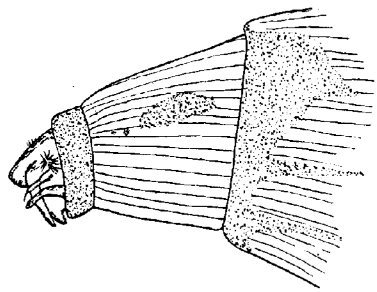


Fig. 16. *T. nigritarsis*, anterior end of adult larva.

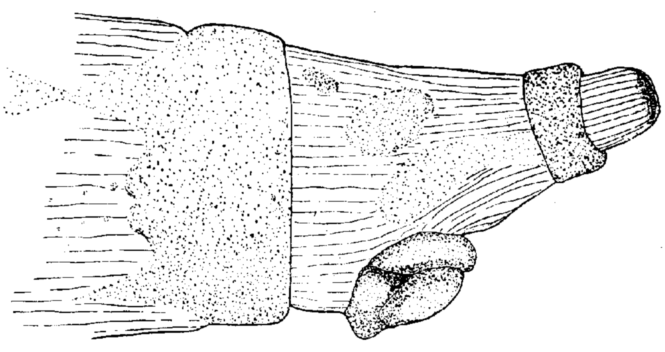


Fig. 17. *T. nigritarsis*, posterior end of adult larva.

dorsum, the 7th is similar, but has some short bristles in the posterior row. The integument of both surfaces bears transverse striae on the anterior two-thirds of each segment, which are generally absent or replaced by punctures on the posterior third. The armature of the terminal segment is variable. In most specimens there

is on the dorso-lateral margins, and midway between the base of the second pair of projecting spurs and the posterior margin of the 7th abdominal segment, a well-developed group of from five to seven very irregular bristles arising from a raised base. In some specimens these bristles are reduced to three or four in number, and in one they are absent on one side and on the other represented by two rudimentary bristles. In the male the anal opening is bordered anteriorly by a semicircle of stout and very irregular bristles, some of which are expanded and branched at the base, others short and almost rudimentary, or all may be long and moderately slender. Posteriorly the opening is bordered by a raised and deeply furrowed prominence. In the female (fig. 18) the fringe of bristles in front of the anal opening is broadly interrupted in the middle, each group being composed of from five to eight bristles of variable size.

The Adult. In life the eyes of the male are dull yellow-green and coarsely facetted above the point of junction of the eyes on the front; below this and on the sides and posterior margin the facets are smaller and bronze-coloured, with gold and green iridescence. In the females the eyes are uniformly dull yellow-green.

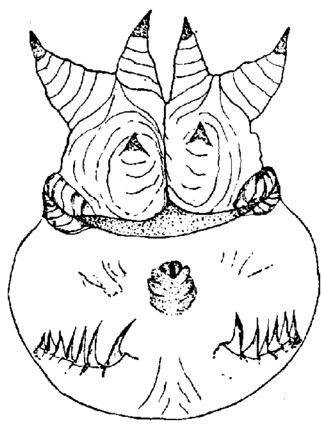


Fig. 18. *T. nigritarsis*, ventral surface of last segment of female pupa.

Seasonal Occurrence. Apart from the three flies reared in the laboratory only two individuals (females) have come under my notice during the period 25th February 1919 to 30th September 1920. Both were captured whilst attacking horses during the last week in February of this year. In the Northern Territory (1912–1917) this species was regarded as the most numerous and most troublesome to stock during the months of December-February. The egg-masses found there were small and compact and were generally placed on the underside of pandanus leaves overhanging water.

Silvius notatus, Ric.

S. notatus, Ricardo, Ann, Mag. Nat. Hist. (8) xvi, 1915, p. 264.

S. psarophanes, Taylor, Proc. Linn. Soc. N.S.W. xlii, 1917, p. 520.

S. fuliginosus, Taylor, *op. cit.* xl, 1915, p. 810.

Distribution. This Tabanid is a widely distributed species, having been recorded from S.W. Australia, Victoria, New South Wales, South Queensland, North Queensland and the Northern Territory (*S. fuliginosus*, Taylor).

Although so widely distributed, it would appear to be a rare species in this district, where, apart from those referred to above, only one specimen (the type of *S. psarophanes*) has been recorded hitherto. Nothing is known of its early stages and the feeding habits of the larvae and adults.

Breeding-places and Habits. On 22nd August 1919, while breaking down and sifting the low banks of a small lily-covered pool (Locality No. 3) about 24 Tabanid larvae were found in nearly dry, stiff, loamy soil at depths below the surface varying from 10 to 30 cm. In most cases the larvae lay in a vertical position with the head uppermost, others lay horizontally, and a few vertically with the head downward. At the time the bank was distant 12 feet from the water's edge and six feet from the mud which intervened between it and more or less dry soil. All the larvae were in the lower part of the bank in soil which had been above water-level since about 12th May, and although a search was made in the mud and adjacent dry soil no larvae were found there. The undamaged larvae, 16 in number, were removed to the laboratory and placed in two five-inch flower-pots containing moist soil, in which they remained undisturbed until 8th October. From the 22nd August until 22nd September they were very restless and wandered over the surface of the soil at night. These movements ceased on the latter date, and on the 8th October about one inch of the surface soil in one pot was temporarily removed, exposing the head and thorax of three pupae. The colour of the eyes and wing-sheaths indicated that they were then from about three to five days old. The oldest was preserved as a specimen, and the others were placed separately in pots of earth, from which they emerged as flies (♂ and ♀) on 13th October after a pupal period of about eight days. On the same date two males emerged from the second pot. Other flies emerged as follows:—1 ♂ on 25th October, 1 ♂ on 3rd November, 1 ♀ on 8th November, 1 ♂ on 24th November, 1 ♀ on 26th November, 1 ♀ 30th November, 1 ♂ 2nd December (pupal period 14 days), 1 ♀ 12th December.

On 15th June 1920 two resting larvae were taken from the bank shown in Plate II, fig. 2, and were transferred to small pots of sand, where they still remain in the larval stage (30th September).

The Larva. The adult larva measures about 33 mm. long by 4 mm. wide and is of a creamy white colour with narrow orange citrine bands at the anterior end of each of the first ten segments. On the first three segments the banding is obscure and on the 11th it is confined to a collar-like expansion of the posterior margin. Each abdominal segment, excepting the last, bears a slightly elevated transverse ridge or tubercle about half as wide as the segment, as well as a pseudopod on either lateral margin and a pair of pseudopods on the ventral surface. Macroscopically the dorsal and ventral surfaces are similar in appearance. The integument is glabrous and bears very distinct longitudinal striae. The first and last segments, and especially the spiracle (figs. 19, 20), differ greatly from those of any species of the genus *Tabanus* known to me. Grabner's organ has not been made out.

The Pupa. The pupa measures from 18–20 mm. in length, 3–3·5 mm. in width across the thorax, and 3·5–4·0 mm. across the widest part of the abdomen. The colour varies, according to age, from chestnut-brown to mars brown, head and apices of wing-sheaths blackish brown, lower surface and sides of first abdominal segment ochraceous tawny. In the male the head is as wide as the thorax, in the female slightly less. The abdomen is nearly cylindrical in both sexes. The thoracic spiracles are large and overlap the posterior margin of the head. The first abdominal segment bears two slender hairs on the tergite and one on each pleurite near the wing-sheath. The second tergite bears an interrupted single row of very short stout and irregular bristles and three or four long bristles, generally towards the sides. The third, fourth

and fifth tergites are similar, except that the bristles are stouter and there are about eight long bristles on each. On the sixth and seventh tergites the bristles are fewer and stouter than on the preceding ones. On the pleura they are arranged roughly in two rows, those in front being much shorter and fewer than those behind. Sternites 2-7 are armed similarly to their corresponding pleurites. On the anterior half of each tergite there are five or six small dark-coloured depressions, the foremost being nearest the pleura and the hindmost nearest the median line. Behind the anterior margin of each segment and parallel with it there is another row of three or four similar depressions on either side of the median line. The anterior two-thirds of each tergite, pleurite and sternite are distinctly marked with transverse striae; posterior to the bristles these striae are less distinct or absent and the whole surface is punctate.

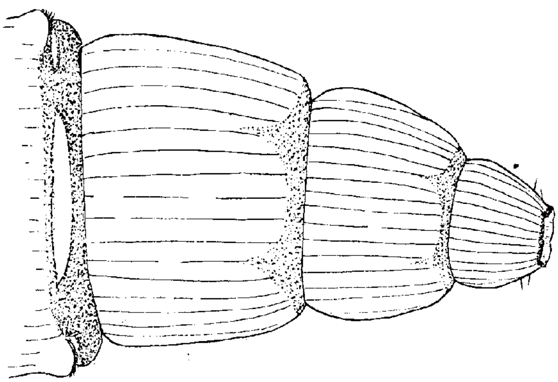


Fig. 19. *Silvius notatus*, Ric., anterior end of adult larva.

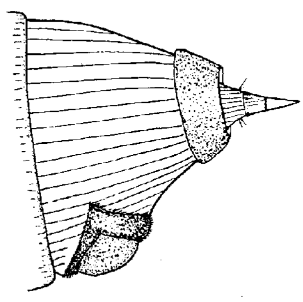


Fig. 20. *Silvius notatus*, posterior end of adult larva.

The terminal segment is deeply rugose, the two upper projecting spurs or bristles are parallel along their inner margins in the female and divergent in the male; the middle pair is much larger than the upper and lower and projects laterally. The anal tubercle of the male is very large and deeply furrowed; in front it is bounded by a continuous fringe of bristles, four or five comparatively small ones in the middle and a group of four or five very stout ones on each side, similar to but larger than

those of the female (fig. 21) ; the latter group of bristles is continued, with a slight interruption, around the sides of the segment to a point in line with the base of the lower pair of spurs. The size and number of these bristles are variable in both sexes, but are generally largest and fewest in the males.

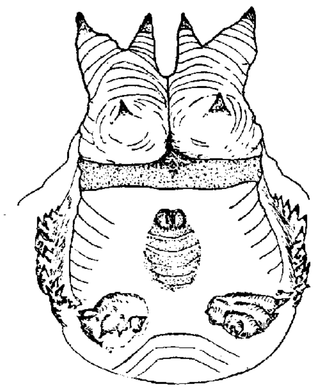
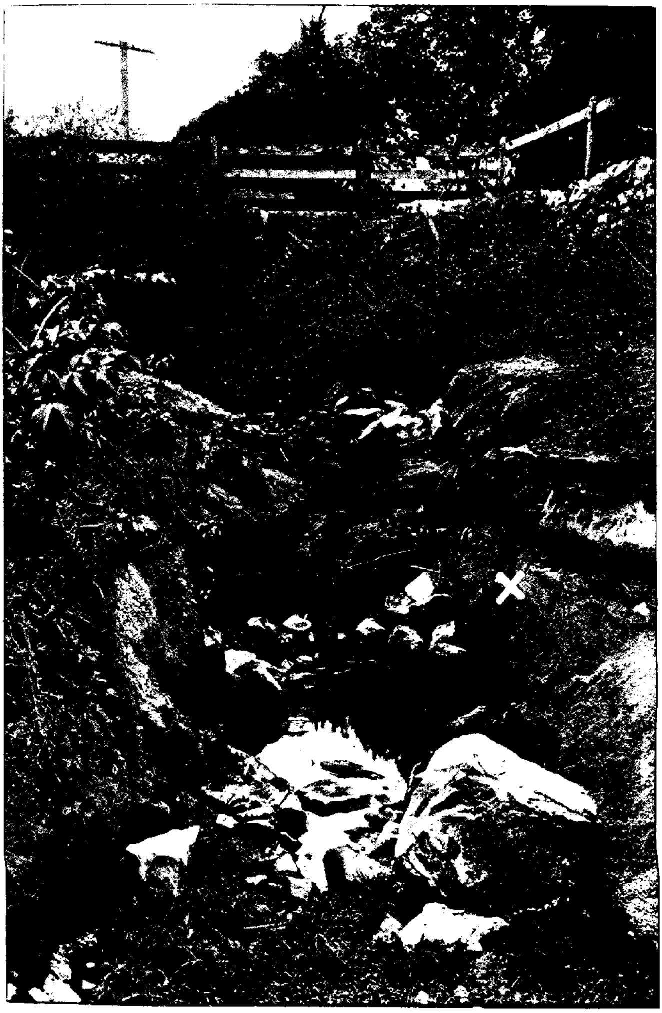


Fig. 21. *Silvius notatus*, ventral surface of last segment of female pupa.

The Adult. In life the eyes of the female are of uniform light seal-brown and the facets of equal size throughout. In the male the greater part of the surface of the eye is of the same colour, but at the lower third it is crossed by a sinuous, iridescent blue-green and copper band, which extends to near the lateral margins and is continued (in light seal-brown) around the posterior margin to the vertex. The facets forming this band are very small, while the remainder are large.



Rock-hole (Locality No. 1), showing spot upon which eggs of *Tabanus aprepes*, Tayl., were laid (marked with a cross).

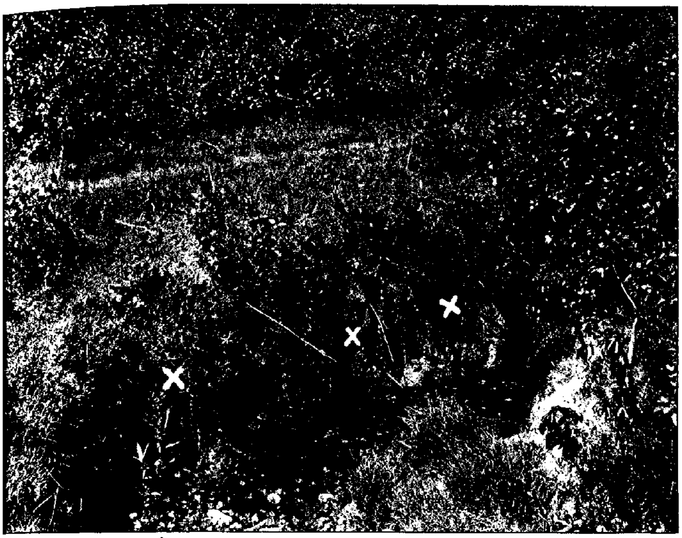


Fig. 1. Pool in stream (Locality No. 1); twenty-five egg-masses of *Tabanus aprepes* were found on grass overhanging the bank.

Fig. 2. Clay bank (Locality No. 3) from which larvæ of *Tabanus aprepes*, *T. rufinotatus*, *T. nigritarsis* and *Silvius notatus* were obtained.

THE LIFE-HISTORY OF *EUTHYRRHINUS MEDITABUNDUS*, FABR., AN IMPORTANT WEEVIL PEST OF MANGO TREES IN AUSTRALIA.

By G. F. Hill, F.E.S.

(Plate III.)

The adults of the weevil, *Euthyrrhinus meditabundus*, Fabr., were frequently taken in the forest country to the south of Darwin, Northern Territory, and on several occasions they were bred from the branches of two species of indigenous trees and from custard apples, Poincianas and two unidentified species of introduced ornamental trees growing in the Darwin Botanic Gardens. As a rule the infestation of these trees was not heavy, although Poincianas occasionally showed considerable injury. Mango trees, which were frequently badly damaged and sometimes destroyed by termites (*Mastotermes darwinensis*), appeared to be immune from attack by *Euthyrrhinus*, even when growing in close proximity to infested trees of other kinds.

Later, while a resident of Townsville, North Queensland, I had opportunities of studying the habits of this insect in the rôle of a mango pest of the first importance. Although these trees are not grown extensively for commercial purposes, they are to be found in many North Queensland gardens, where they are prized not only for their shade and beauty, but also for their prolific crops of fruit.

The following notes are the result of observations made on a number of large mango trees growing in the vicinity of the Australian Institute of Tropical Medicine, Townsville. In March 1919, two trees in particular attracted attention owing to the number of dead twigs appearing through the dense foliage at the summit, and although a close examination was not made then, the condition was attributed to the effects of drought during the preceding dry season. During the dry season of 1919 (April to the end of December) the condition of these trees gradually became worse, and others in the vicinity showed symptoms of disease. Early in this year (1920) one tree threw out bunches of leafy shoots along the main and upper branches, but the older foliage continued to fall. At the end of April this tree died, and of the other there remained alive only one secondary branch and a strip of bark extending from it to the ground. From that month (April) to the end of August the beetles emerged in great numbers from the trunks and main branches. Those beetles which emerged from the now dead tree migrated at once, presumably to living trees in the vicinity, while those from the other gathered on, and oviposited in, the remaining living portion.

Upon emerging from their holes the beetles are very active and begin at once to seek mates. The act of copulation occupies about ten minutes, after which the male remains attached to the female for some considerable time—two or three hours in some cases. During copulation the females, and afterwards both sexes, gnaw away the outer weathered surface of the bark and feed upon the living tissues or sap beneath, leaving small areas of exposed tissue to mark the feeding places. This injury is negligible, even when many beetles are confined in close captivity to a small area of bark.

Oviposition.

The average period of development of the embryo within the ovary has not yet been satisfactorily determined. On 6th August a pair were observed copulating at noon, and an hour later they were removed to a healthy mango tree, on which they were enclosed in a small wire-gauze cage tacked to the bark. During the following three

days the male was generally found clinging to the female, but copulation was not again observed. The male died on the sixth day, and on the eighth day the female was seen to have the proboscis deeply buried in the tissues of the bark, apparently engaged in preparing a hole in which to insert an egg. Later in the day she was attacked and crippled by small ants (*Pheidole megacephala*). On the following day she was dissected, and an egg was found in the oviduct. Later two batches of six couples each were confined on the bark of the same tree in a similar manner. Most of the males died within ten days, and on 29th September there remained alive only one female of one batch and three of the other. On the latter date the cages and their contents were removed to fresh sites for further observation, and the bark previously covered by the cages was carefully examined for eggs or larvae. Although the surface showed numerous punctures, some of which extended to a depth of 3 mm., no trace of eggs or larvae could be found. The reason for this apparent delayed oviposition has not yet been determined, but it may be found to be due to refusal to oviposit in captivity even under conditions so closely simulating nature.

At noon on 8th September a wild female was observed with the proboscis inserted in the bark to a depth of about 3 mm. At 5.30 p.m. the hole was found to be plugged with comminuted bark, under which an egg lay 2 mm. from the surface. This egg was removed *in situ* to the laboratory, where it hatched 7 days later. About this time several other eggs were found in similar circumstances.

The egg is a rounded oval measuring 0·528 mm. in width by 0·688 mm. in length, pearly white in colour, with a very finely granulated surface.

Larval Development.

Upon hatching the young larvae tunnel into the bark, subsequently, and while yet very small, boring into the sapwood, obliquely or horizontally at first, but always horizontally sooner or later. The duration of the larval and pupal stages has not yet been ascertained, but it is believed to total 12 months at least. Experiments designed to determine these points, and also the length of life of the perfect insects, are in progress.

Appearance of Infested Trees.

The earliest observed symptoms of infestation are pronounced withering of the terminal twigs, followed by partial defoliation, the development of numerous adventitious tufts of foliage (Plate III), and the death of the secondary and, later, the main branches. The cause of these conditions is not manifest until the perfect insects begin to emerge from the dead or dying branches or, very rarely indeed, from branches in which there is still a flow of sap. As a rule the injury caused by the larvae is such that the branch is destroyed before the first beetles emerge.

The bark of a heavily infested branch will be seen to be pierced by numerous clean-cut holes (fig. 1) of various sizes, ranging from 1·5 mm. to 7 mm. in diameter, the smallest of which, *i.e.*, those up to about 2 mm. in diameter, are made by the adults of Hymenopterous parasites which have in the larval stage destroyed the young *Euthyrrhinus* larvae, the larger by adult weevils. The latter holes vary a good deal in size in accordance with variations in the size of the adults, *i.e.*, from 2 mm. to 6·5 mm. in width by 4·5 mm. to 12·5 mm. in length. The males are generally, if not always, very much smaller than the females; but this statement appears to be often contradicted by the finding of pairs of approximately equal size in a copulatory attitude. If, however, these pairs are dissected they will be found to be females.

On the removal of the bark the sapwood shows a few shallow surface grooves made by the young larvae before commencing their drive towards the heartwood, but more often they bore straight in towards the centre without preliminary tunnelling. A large proportion of the young larvae fail to penetrate deeper than 5 or 6 mm. before

they are overcome by parasitic Chalcids. The survivors penetrate much deeper—*i.e.*, from 30–35 mm.—and when nearly full-grown turn about so as to direct the head outward. In this position they enlarge the burrow to one uniform diameter from its base to near the cambium, the frass accumulated in the process being very tightly packed behind so as to fill from 10–22 mm. of the burrow, in the remaining portion of which pupation takes place.

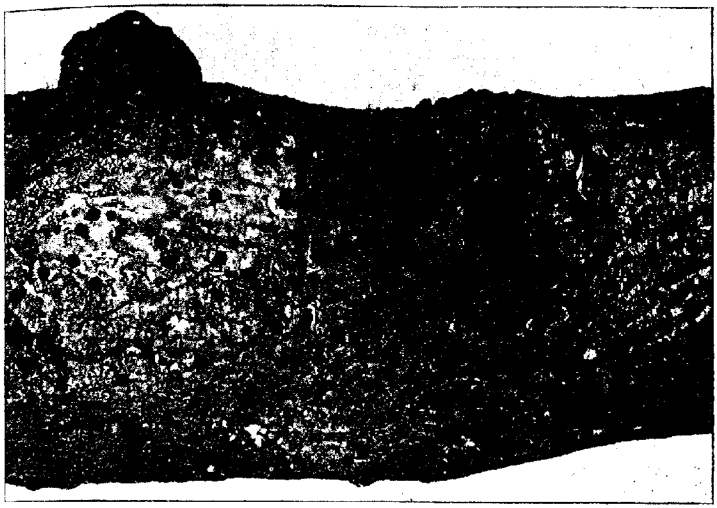


Fig. 1.—Main branch of a mango tree after the emergence of the weevils.

On emerging from the pupal stage the imago appears to undergo a rather long developmental stage within the pupal chamber, during which the body hardens and the insect becomes sexually mature.

The operation of boring its way out through the thin layer of sapwood and the bark which lies between the chamber and freedom is evidently a long and tedious process, judging by the notches worn on the sides of the hole by the leg joints of the toiling insect.

Parasites.

Early in August, when the beetles were first noticed to be plentiful, a species of Chalcid wasp was frequently found in close association with them, or on adjacent foliage. Selecting a branch from which *Euthyrrhinus* were then emerging and which showed, in addition to their exit holes, a few smaller holes in the bark, two pieces, each about 2 feet in length, were sawn off and removed to a cage, where during the next few weeks about a dozen of the Chalcids emerged. On examination it was found that these insects had developed in holes about half an inch deep, which had been made by the young weevil larvae prior to being parasitised. Mr. A. P. Dodd, to whom specimens were submitted, informed me that, although known to him from the Cairns district, they belong to a new species, a description of which, under the name *Chalcis euthyrrhini*, appears below. A few weeks later several specimens of *Thaumasura curculionis*, Girault, were reared from the same branch and from the feeding-holes of young larvae of the same host. About the same time both parasites were also captured on

mango trees infested with *Euthyrrhinus*. It may be remarked here that the type and other specimens of *Thaumasura curculionis* were reared by me in Darwin (Northern Territory) from the branches of custard-apple trees and an undetermined introduced tree infested with *Euthyrrhinus meditabundus*. A third and somewhat similar Chalcid, of which a single specimen only has been secured, is also a parasite of this weevil. Mr. Dodd has identified this species as *Thaumasura pavo*, Girault. In addition to the above, two specimens of a much smaller parasitic wasp were bred from the eggs of this host, while a rather brightly hued Braconid has been taken frequently on infested branches. Although the latter has not been definitely associated with *E. meditabundus* as a parasite, there is little doubt as to its relationship with the latter.

It is only too evident that these parasites have not proved themselves to be of much practical value in controlling this pest, and that artificial means must be resorted to if efforts are to be made to prevent the destruction of these valuable shade and fruit-producing trees.

Artificial Methods of Control.

No experimental work has been attempted with the object of devising means for combating the ravages of this insect, a pest which will probably prove difficult to control, and for several reasons. The adults are capable of flight as soon as they emerge from their burrows in the wood; and certainly disperse soon after emergence from trees which do not provide suitable conditions for rearing future broods. For this reason badly infested trees should be cut down and burnt before the adults leave them, for it is evident they cannot be saved once the main branches and trunks show evidence of heavy infestation. Whether the spread of the beetles from infested to healthy trees could be effectively checked by this means remains to be proved, but there is some evidence to suggest that such a measure would have the effect of localising the area affected.

Mango tree, showing effects of attack by a weevil,
Euthyrrhinus meditabundus, Fabr.

A NEW CHALCID PARASITE OF *EUTHYRRHINUS MEDITABUNDUS*.

By Alan P. Dodd.

Chalcis euthyrrhini, sp. nov.

♀.—Length, 5–7 mm.

Head and thorax black; abdomen bright orange-red; tegulae red; antennae clear orange-red, the two apical club joints darker, the scape darker and varying to black; posterior legs, including the coxae, clear orange-red; anterior and intermediate coxae black, their femora and tibiae more or less brown or fuscous, their tarsi red.

Head, viewed from above, transverse, the occiput concave and (from lateral aspect) declivous, immargined; frons gently yet distinctly convex from eye to eye, viewed from in front distinctly wider than deep; antennal scrobes long, narrow, reaching to and hardly containing the median ocellus at base, divided by a wedge-shaped elevation that tapers to a point at half their length; eyes large, bare; ocelli large, in a slightly curved line, the lateral pair separated from the median ocellus by less than their own diameter; cheeks broad; surface with dense uniform umbilicate punctures. *Antennae* separated at base, inserted slightly above a line drawn across ventral end of the eyes, 13-jointed, counting the club as 3-jointed; scape slender, as long as the next four joints combined; pedicel not much longer than its greatest width; ring-joint large, narrowed at base; funicle 1 twice as long as its greatest width, 2 slightly longer than wide, 7 a little wider than long; club conical, fully twice as long as its greatest width, the first suture distinct and slightly before the middle, the second suture faint. *Thorax* normal, sculptured like the head, the sculpture very coarse, without conspicuous pubescence; pronotum large; its posterior margin deeply concave, the scutum thus much produced at meson anteriorly; anterior margin of scutum with dense scaly sculpture, rising sharply from the pronotum; scutellum hardly longer than its greatest width, its apical plate rounded; axillae rather widely separated; propodeon almost perpendicular in relation to the scutellum, moderately long, coarsely rugose and also finely shagreened, with a shallow median channel, laterally and near anterior margin with a distinct subacute tooth or projection on either side; pleurae sculptured like the rest of the thorax, the mesopleural depression longitudinally striate. *Fore-wings* ample, normal, stained yellowish, venation black; marginal vein three times as long as the stigmal, which is as long as the post-marginal. *Abdomen*, viewed from above, pointed ovate, fully twice as long as its greatest width, the valves of the ovipositor slightly exserted; gently convex above and beneath, no longer than the thorax; segment 2 (first body segment) almost as long as the others united, 3 longer than 4, 5 and 6 subequal and shortest, 7 fully as long as 4–6 combined, 8 rather short and with a median carina; 2 smooth and polished; 3–6 smooth, except for yellowish pubescence against their anterior margins, no setae at meson, the free area broader on 3, narrower on 6; 7 with rather dense shallow punctures and yellow pubescence; 8 pubescent. *Legs* normal; teeth on hind femora varying from eight to eleven, counting from base, 1 largest, 2 usually small and also usually the apical one or two.

♂.—Similar to the female, except that the pedicel is fuscous, also all the club and preceding joint; antennae as in the female, but the pedicel is smaller, the apical funicle joint is as long as wide, and the club is somewhat shorter; abdominal segments 5 and 6 comparatively longer, 7 shorter, the abdomen blunt at apex.

North Queensland: Cairns district and Townsville.

Described from two females and one male received from Mr. G. F. Hill, and a large number of females and one male collected by the author in January, March, May, September, October and November. Mr. Hill's specimens were bred from the Curculionid beetle, *Euthyrrhinus meditabundus*. Of the author's material, several

were bred from dead wood of the mango tree, and the remainder captured on dead or dying timber frequented by the same weevil; it was found easy to collect a series by visiting the same tree for an extended period, one or more specimens being caught daily.

The host record is of considerable interest, inasmuch as the other members of the genus attack Lepidopterous and Dipterous larvae.

The diversity in habits of this species probably has some connection with the several minor structural differences. The convex frons, narrow antennal scrobes, concave occiput and produced scutum are peculiarities which might be given generic value, but a study of a series of species would need to be entered upon. The author has an unnamed species, collected in company with *Chalcis euthyrrhini* and probably with similar habits, which shows the same characteristics.

There is little variation in colour; the abdomen and posterior legs remain constant, and the degree of variation in the first two pairs of legs and the antennae is not great.

Asymmetry in the femoral teeth is common; there may be nine teeth on one femur and eleven on the other, or nine on one and ten on the other; the femora of numerous specimens were examined.

Type. In the collection of the Queensland Museum, Brisbane.

Cotypes. In the collections of Mr. G. F. Hill and the author.

MOSQUITO NOTES.—II.

By F. W. EDWARDS.

(*Published by permission of the Trustees of the British Museum.*)

nopheles flaviceps, sp. nov.

Head with the integument rather light yellowish, especially when viewed from in ont. Erect scales mostly brown, a small area of white ones in the middle towards ie front, and in front of these a few long, narrow recumbent scales, not forming definite frontal tuft. Many light brown bristles between the eyes; border bristles ark. *Antennae* with the basal joint yellow; in female with a few small scales on the econd joint; male plumes light brown. *Female palpi* very slightly longer than the roboscis, thin, with appressed scales; narrow whitish rings at the tips of the first iree joints, just extending on to the bases of the succeeding joints; tip of last joint ark. Second joint slightly longer than the first, slightly shorter than the third nd fourth together; fourth joint less than half as long as the third. [*Male palpi* iissing.] *Proboscis* dark, except for the labella.

Thorax rather light yellowish, darker in the females (perhaps through discoloration). lesonotum somewhat shining, not darker at the sides, with light bristles, and in the iiddle with rather numerous, very narrow hair-like scales. Prothoracic lobes rounded, ot mammillate, without scales. Prosternal hairs, five or six.

Abdomen light brown, with narrow dark bands in the male; hairs pale; no scales. *Iale hypopygium*: Basal spines, five or six, all rather strong, in a loose, irregular luster; one distinctly distal to the rest and much longer, but not more slender. laspettes pointed; a long and fairly strong apical hair, half as long again as the club, hich is normal in shape, but much more basally placed than the hair; no accessory airs discernible. Tip of mesosome with about five rather narrow leaflets; the longest ·55 as long as the mesosome.

Legs dark; extreme tips of femora and tibiae and extreme bases of tibiae pale; n the front and middle legs the tarsal articulations are also just perceptibly pale nder a strong lens. All femora slender, cylindrical.

Wings: Costa dark on basal two-fifths, in one wing of one specimen with a small ale spot included near the base; apical three-fifths with four yellowish patches lternating with three dark ones, of which the third is the smallest, the first being istinctly larger than the adjacent light ones. A small dark spot at the wing-tip pposite apex of upper fork-cell. First vein light with four dark patches, the first eing below the apical part of the dark basal two-fifths of the costa, the others below ie remaining dark costal spots. Remainder of wing without conspicuous markings, ut there are pale areas round the cross-veins, and the bases of the fork-cells, the base f the second vein, the middle half of the third vein, and the extreme tips of the econd, third and fourth veins are also pale. Vein-scales linear, rather short and ot very dense.

ANGLO-EGYPTIAN SUDAN: Erkowit, 5.vi.1917, 1 ♂ (type), 1 ♀, also 1 ♀ from the ame place, 22.v.17 (*H. H. King*).

Type in the British Museum, presented by the Imperial Bureau of Entomology.

Apparently most nearly allied to *A. turkhudi*, Liston, and *A. hispaniola*, Theo. which may be a local form of *A. turkhudi*), but differing in the paler colour of the itegument, especially of the head, almost obsolete frontal tuft, more numerous rosternal hairs, more shining mesonotum, and somewhat less conspicuous wing iarkings; also in the male hypopygium in the more pointed claspettes, which have o accessory hair and a more basally situated club, and in the stronger detached asal spine.

Anopheles immaculatus, Theobald.

Swellengrebel and Swellengrebel de Graaf have recently suggested (Bull. Ent. Res., xi, p. 78, 1920) that this may be an albinoid form of *A. vagus*, Dönitz. An examination of the hypopygium of a male from Java presented to the British Museum by Dr. Swellengrebel supports this possibility, since no tangible differences could be discovered between the hypopygia of the two forms.

Anopheles leucosphyrus, Dönitz.

Two rather well-marked forms of this species occur :—

(1) The typical form. Female palpi with the white rings distinct, the last joint white on at least its apical half. Proboscis of normal length, little, if any, longer than the palpi. Dark markings of wings less extensive ; the spots on the first longitudinal vein more broken up.

(2) Var. *hackeri*, nov. Female palpi with the white rings very narrow, the last joint white only at the extreme tip. Proboscis unusually long, longer than the palpi by almost, or quite, or even more than, the length of the last two palpal joints. Dark markings of wings more extensive ; the spots on the first longitudinal vein more fused.

The var. *hackeri* has recently been noted by Dr. H. P. Hacker (Fed. Malay States, Malaria Bureau Reports, ii, p. 33, 1921). A specimen collected by him and presented to the British Museum is designated as the type ; the Museum collection also contains a number of others from the Malay States, from Dr. Leicester's collection. The distinction in colour between the palpi of the two forms is quite sharp, and in length also it is very striking, but variable. Most specimens of the typical form have the palpi as described, almost, or quite, as long as the proboscis. However, among a small number from Borneo collected by Dr. Roper there is one which has an elongate proboscis like that of the dark form. Probably, therefore, the two forms are not specifically separable.

Anopheles punctulatus, Dönitz.

This species has recently been discussed by Swellengrebel and Swellengrebel de Graaf (Bull. Ent. Res., xi, p. 89, 1920), who concluded that it was not specifically distinct from *A. tesselatus*, Theo., and at the same time described a very similar form under the name *Nyssorhynchus annulipes* var. *moluccensis*. Finding that the description of *moluccensis* agreed rather closely with my conception of *punctulatus*, I wrote to Dr. Swellengrebel, suggesting that the two were the same, and received the following reply :—

" As to Dönitz's *punctulata*, there can be no doubt, judging from the published photograph, that its proboscis is white on the apical half. Moreover, the black ring near the apex of the second palpal joint is very narrow. This induced me to separate *moluccensis* from it, and I still think that the specimen from which the photograph was taken (probably the type) is a *tesselata*. As a general rule I believe it is well, from a practical point of view, to separate these allied forms, if, at least, a separation is practicable ; some of them may prove to be good carriers and others not (*rossii* and *ludlowi* !)."

After a close study of the literature and the British Museum collections, somewhat different conclusions seem to be indicated from those arrived at by Dr. Swellengrebel.

All the specimens in the Museum series of *A. punctulatus* prove to be practically identical with *moluccensis* in palpal markings, and most of them also agree in having the proboscis entirely black. One or two, however, including a specimen determined by Dönitz and coming from his type locality (Stephansort), show a pale area on the underside of the proboscis towards the tip. The colour of the proboscis cannot, therefore, always be used to separate *moluccensis* from *tesselatus*. I cannot agree

vith Swellengrebel in placing *moluccensis* as a variety of *annulipes*; the latter, part from its much larger size, shows some quite good differences in the wing-narkings.

The three forms under consideration appear to be separable as follows (in the emale sex) :—

(1) *A. punctulatus*, Dönitz, typical form. Proboscis pale on the apical half, at least n the underside. Second joint of palpi about equal in length to the third and fourth ogether; its basal half black, and a narrow dark ring close to the tip of the white pical half. New Guinea.

There is no specimen exactly answering to this description in the British Museum, nd Swellengrebel states that he has not met with it. Probably, therefore, Dönitz nay have described and figured a somewhat aberrant specimen of the following. .

(2) *A. punctulatus* var. *moluccensis* (Swellengrebel). Proboscis entirely black, or vith a rather small pale area on the underside towards the tip. Second joint of palpi narkedly longer than the third and fourth together; its basal three-fifths or more lack, and a broader black ring towards the tip. New Guinea; Moluccas.

This is *A. punctulatus* in the sense in which I have previously understood it.

(3) *A. punctulatus* var. *tesselatus*, Theobald. Proboscis pale on the apical half above and below). Second joint of palpi markedly longer than the third and fourth ogether; its basal half black, its apical half entirely white. Oriental Region; also eported by Swellengrebel from Ceram, but this may prove to be the true *punctulatus*.

Anopheles amictus, sp. nov.

Differs from *A. annulipes*, Walker, as follows:—Proboscis entirely dark-scaled in oth sexes. Antennae of the female shorter and stouter, especially the last few oints, which are neither thinner nor longer than those immediately preceding, the last en joints all being of about the same length and thickness. Abdomen rather densely lothed with broad, flat scales on all segments except the first; on the dorsal surface he scales are mostly yellowish, with a patch of dark ones in the middle of segments 1–6; on the ventral surface the scales are mostly whitish and less numerous towards he base. White spots on the legs larger, the posterior surface of the front tibiae eing almost entirely white. First longitudinal vein with 14–18 small black spots; o long ones.

QUEENSLAND: Townsville (*G. F. Hill*), type ♀ and one ♂, presented by the mperial Bureau of Entomology.

The differences between this and *A. annulipes* seem to be too great to fall within he limits of specific variation, especially as regards the abdomen and antennae; nevertheless, the two are certainly very closely allied, and some specimens show ntergradation in some respects. A female from Townsville, 2.ii.1903 (*F. P. Dodd*), grees with the above definition, and also shows a further difference from *A. annulipes* n that the second, third and fourth joints of the hind tarsi have distinct whitish ings at the base as well as at the tip. A female from Port Darwin agrees with this. A female from Townsville (*F. H. Taylor*), and another from Cardington, Queensland F. H. Taylor), have the scaly abdomen of *A. amictus*, but the antennae are somewhat nore slender apically, the proboscis is pale on the apical half, the integument of the nesonotum is ochreous, and the first vein has long black spots. The last two specimens nay possibly be *A. mastersi*, Skuse, but regarding both *A. mastersi* and *A. musivus* Skuse states that the *last* abdominal segment bears scales, implying that the others lo not. Besides the above-mentioned forms, examples of normal *A. annulipes* have een taken at Townsville.

Megarhinus (Toxorhynchites) kempi, sp. nov.

♂. *Head* blue-scaled (? rubbed). Proboscis purple, the thin portion with a greenish tinge. Palpi rather longer than the proboscis, slender; first three joints about equal in length, mainly yellow-scaled, some purple scales, chiefly on upper surface, towards bases of first and second, and at apices of second and third. Fourth joint dark, acuminate, nearly as long as second and third together. Clypeus and basal antennal joints bluish-grey-dusted, shaft of antennae yellow; first flagellar joint with a few dark scales. *Thorax*: Prothoracic lobes clothed with deep blue scales, a few white ones beneath. Pro-epimera and pleurae with silvery-white scales. Mesonotum black, scales mostly metallic green, with some purple ones intermixed (very much rubbed). *Abdomen* without apical lateral scale tufts; dorsal surface mostly metallic purplish blue; first tergite green; remaining tergites each with a narrow basal band of bluish green. Venter mostly yellow; no median purple line; eighth sternite purple. *Legs*: Femora purple above and in front, yellow beneath. Tibiae purple. Tarsi purple, the first joint on all the legs with a rather narrow and ill-defined whitish ring near the base. First hind tarsal joint with rather long and dense bristles beneath, except at the base. Front and middle claws unequal, the larger with a strong median tooth, the small simple; hind claws equal and simple. *Wings* as in *M. leicesteri*. *Hypopygium*: Ninth tergite rather narrow, the bare middle part slightly emarginate apically, fully twice as wide as long; side portions each with 10–12 long hairs. Ninth sternite bare. Side-pieces tapering, nearly three times as long as their basal width; basal lobes triangular, apically with two long and strong bristles. Claspers slightly shorter than the side-pieces, of even width throughout, terminal spine long, strong and pointed; about five fine hairs in a row before the tip. Tenth sternites long and rather slender, their tips not conspicuously enlarged or blackened. Lower bridge of mesosome very narrow and nearly basal; paired processes of mesosome rather slender, distinctly but irregularly serrate above (sternally).

♀. Palpi purple, not longer than the head. Head with mixed colours, mostly blue above and pale round the eyes. Prothoracic lobes purple. Mesonotal scales bright metallic green. White rings on the first tarsal segments more distinct than in the male; the tarsi have also additional white markings as follows:—on the front and middle legs, a small area at the base of the second joint on the underside; on the front legs, the inner and lower side of the fourth joint, except its tip, and the underside of the fifth joint; on the middle legs, practically the whole of the fourth and fifth joints, except the tip of the latter on the upper side. (The last four joints of the hind tarsi are missing.)

INDIA: Talewadi, nr. Castle Rock, N. Kanara district, 3–10.x.1916 (*S. Kemp*), 1 ♂ 1 ♀. *Type* in the Indian Museum.

Closely resembles *M. leicesteri*, Theo., which differs chiefly in having the whole of the last four joints of the middle tarsi of the female white; the ninth tergite of the male is broader, and the paired anterior processes of the mesosome are not serrate.

Megarhinus (Toxorhynchites) klossi, sp. nov.

♂. Differs from *M. kempi* as follows:—First joint of palpi a little shorter, third a little longer than second. Scales of prothoracic lobes all purplish blue; those of pro-epimera coppery above; of mesonotum duller, purplish and bronzy, mixed with green; of scutellum coppery. Sides of first abdominal tergite whitish. Ninth tergite broader; tenth sternites more enlarged apically; lobes of mesosome smooth above; clasper with hair-like terminal spine. First hind tarsal joint without dense bristles beneath. From *T. gravelyi* the differences are:—Distinct basal bands are present on the abdominal tergites; ninth tergite is less emarginate; venter is without median purple stripe, etc.

FED. MALAY STATES: Kedah Peak (Gunong Jerai), 3,200 ft., xi–xii.1915 (*C. Boden Kloss*), 1 ♂. *Type* in the British Museum.

Megarhinus (Toxorhynchites) gravelyi, sp. nov.

♂. *Head* mostly dark-scaled (colour varying with the light), a pale rim round the eyes. Proboscis purple, more greenish on the thin apical portion. Palpi slender, slightly longer than proboscis; first joint distinctly shorter than the second or third, which are about equal in length, and together about as long as the fourth; the palpal scales are purple, on the underside of the first three joints, except towards the tip of the third and the base and extreme tip of the second, mostly golden. Second antennal joint with some golden scales. *Thorax*: Prothoracic lobes and pro-epimera coppery-scaled above, silvery white below; pleurae silvery-white-scaled; mesonotal scales bright metallic green; scutellar scales coppery, a few whitish ones at the sides. *Abdomen*: First tergite bluish green in the middle, shining creamy white at the sides; remaining tergites deep blue, with basal lateral creamy spots. A few yellow hairs at the sides of tergites 6 and 7, not forming definite tufts. Venter golden, with a narrow median purple line; eighth sternite purple. *Legs* purple-scaled; femora golden beneath and towards the base; first joint of all tarsi with a narrow indistinct pale ring near the base (joints 3–5 of hind tarsi denuded). First hind tarsal joint without dense bristles beneath. *Wings* with the cross-veins nearly in a line, the m-cu cross-vein somewhat oblique outwardly. *Hypopygium*: Ninth tergite strongly emarginate apically, narrow in the middle, with well-developed hairy lobes, each bearing 10–15 hairs. Ninth sternite bare. Side-pieces tapering, hardly more than twice as long as their width at the base. Basal lobes with three strong bristles, one weaker than the others. Tenth sternites stout, blackened and somewhat enlarged apically. Claspers as long as the side-pieces, slightly tapering at the tip, terminal spine long, strong, pointed. Mesosome with the lower bridge very narrow, basal; lobes rather slender, smooth above.

INDIA: Pashok, Darjiling district, 2,000 ft., E. Himalayas, 26.v.–14.vi.1916 (*F. H. Gravely*), 1 ♂.

Type in the Indian Museum.

Resembles *T. metallicus*, Lin., differing in the darker upper side of the palpi, coppery rather than purple scales on upper part of prothoracic lobes and pro-epimera; presence of pale rings on first tarsal joints, and more emarginate ninth tergite.

Opifex fuscus, Hutton.

This species was originally described from New Zealand by Hutton (Trans. N.Z. Inst., xxxiv, p. 188, 1902) as a Tipulid, and its true position has not till now been recognised. Recently a number of specimens have been presented to the British Museum by Mr. G. V. Hudson, taken on the ocean beach at Wellington, N.Z.

The insect is a Culicine mosquito, presenting many remarkable features; though its peculiarities seem to be mainly connected with sex, it certainly cannot be placed in any previously known genus of Culicidae, and it is difficult to place it precisely in relation to the other genera of the CULICINI. It seems to be nearer to *Aëdes* than to *Culex*. The following are the most striking features:—

Male.—Antennae rather stout, not plumose, the terminal joints not lengthened; the first joint conspicuously hairy; the third, fourth and fifth joints a little shorter than those which follow, and each bearing a strong spine at the base on the upper side, the spine on the fifth joint very long. Proboscis and palpi strongly curved; the palpi two-thirds as long as the proboscis, the last joint forming a club. The head has no upright scales, these being replaced by hairs. Eyes well separated. Abdomen in several specimens curled under the thorax. Hypopygium with the side-pieces simple, broad at the base, pointed at the tips, a membranous strip along the inside from base to tip; clasper subapical, short, with strong terminal claw and sub-basal projection; anal segment well developed, tenth tergites hairy, tenth sternites each ending in a single strong sharp point; aedeagus of simple structure, resembling that

of *Ochlerotatus*. Femora and tibiae stout, especially on the front legs, where the tibiae are swollen and very short, not more than two-thirds as long as the femora. Fifth joint of front tarsi very small, not longer than broad, but the claws enormous, longer than the last three tarsal joints together, equal, simple, divaricate. Claws of middle and hind legs moderately large, equal and simple. Wings as in *Aëdes*.

Female.—Antennae and front legs not specially modified; claws all simple. Palpi about a quarter as long as the proboscis. Abdomen rather blunt; cerci rather short and broad; eighth sternite very large.

The peculiar antennae and front legs of the male must have some special biological significance, and it is to be hoped that New Zealand collectors will be able shortly to work out the life-history of the insect.*

Leicesteria annulipalpis (Theobald).

In my paper on the genus *Leicesteria* (Bull. Ent. Res., iv, pp. 255–263, 1914) I expressed doubt as to the correct location of *L. annulipalpis*. Recently, however, a female has been received from Dr. N. H. Swellengrebel, taken at Mandailing, Sumatra, which shows that the species really is a true *Leicesteria*. This Sumatran specimen agrees with Theobald's description, except that the claws show a slight swelling towards the middle, which evidently represents a tooth.

Aëdes (Stegomyia) dendrophila, sp. nov.

Closely related to *S. fraseri*, Edw., differing almost solely as follows:—Middle femora without a white spot in the middle in front. Hypopygium of male with the side-pieces shorter, less than twice as long as their breadth at the base; basal lobes larger, more densely hairy; *claspettes entirely unrepresented*; claspers shorter, straighter, and less attenuated apically.

Gold Coast: Nsawam, 16.iii.1920 and 14.iv.1920, 2 ♂, 3 ♀, reared from larvae in hole in cotton tree; Oblogo, 17.iv.1920, 3 ♂ (including type), 2 ♀, from tree-hole; Aburi, 6.vi.1920, 5 ♂, 2 ♀, from banana (*Dr. A. Ingram*). Sierra Leone: Freetown, ix.1914, 1 ♀ from tree-hole (*Dr. G. Butler*, presented by *A. Bacot*); previously recorded as *S. fraseri*.

The absence of a white spot on the mid femora would place this species with *S. pseudonigeria* in my key (Bull. Ent. Res., iii, p. 8, 1912). The new species differs from *S. pseudonigeria* as follows:—All tibiae with small whitish spots at the extreme base, not removed from the base, beneath; mid femora all black on posterior surface, except for the apex; second joint of mid tarsi all yellowish white, except beneath towards tip (in *S. pseudonigeria* white at the base only); last two joints of hind tarsi with some dark scales beneath; segments 2–5 of abdomen with narrower whitish basal bands or none.

Aëdes (Ochlerotatus) bancroftianus, sp. nov.

Head clothed almost entirely with broad, flat scales, a rim of narrow ones round the eyes; the flat scales varying in colour from dark brownish to cream-coloured, generally paler towards the nape; the narrow scales ochreous; ocular bristles pale. Torus ochreous, darker on the inner side. Proboscis dark-scaled and slender throughout, one-third longer than the front femora. Palpi dark-scaled; in the female about one-sixth as long, in the male of exactly the same length as the proboscis; last two joints in the male slightly swollen, with well-developed hair-tufts, the terminal a little shorter than the penultimate. *Thorax* brown, mesonotum clothed in the type with moderately

* Since writing this I learn that Mr. D. Miller, Government Entomologist in New Zealand, has an account of the life history of this insect in course of publication. Larvae and pupae of the species have been received from Mr. G. V. Hudson; they show some resemblances to *Armigeres*.

dark brown narrow scales; ochreous narrow scales round the front margin, round the ante-scutellar space, and in two lines extending from the scutellum for nearly half the length of the mesonotum; in other specimens the dark scales are lighter and the pale scales are more numerous, forming an indistinct pale median transverse band. Scutellum with narrow pale ochreous scales. Prothoracic lobes with broadish curved scales; pleurae with broad flat white ones. *Abdomen* ochreous, with dark brown scales dorsally; tergites 2–4 with complete basal creamy bands, broadening somewhat laterally, 5 and 6 with lateral basal creamy spots. Venter pale-scaled, sternites 4–6 with dark apical bands. In the female the seventh segment is remarkably small, narrow, and partly retracted; the cerci are long and narrow, nearly three times as long as broad. *Male hypopygium*: Side-pieces nearly cylindrical, almost four times as long as their width at the base, without lobes, but with an aggregation of hairs into a small dense patch at the base of the lower flap. Claspettes entirely unrepresented. Claspers long, the outer third rather suddenly narrowed and curved inwards; terminal spine long, slender, almost straight. Lobes of ninth tergite small, with a few short bristles. Mesosome rather short and broad, simple. Anal segment normal. *Legs* entirely dark-scaled, except for the undersides of the front and middle femora, and the greater part of the hind femora, except the tip and a line along the upper side of the outer half. Claw-formula:— ♂ 2 : 1. 1 : 1. 0 : 0; ♀ 1 : 1. 1 : 1. 0·0. *Wings* entirely brown-scaled; scales of the lateral series long, linear, those of the median series also rather long. Cell R_2 as long as its stem in the male, longer in the female, its base slightly proximal to that of cell M_1. *Halteres* ochreous, knob somewhat darker. Wing-length 3·5–4 mm.

QUEENSLAND: Eidsvold (*Dr. T. L. Bancroft*). Type female, 12 other females, and 3 males presented to the British Museum by the Imperial Bureau of Entomology; received through Mr. G. F. Hill.

The only near ally of this species is *O. multiplex*, Theo., which differs in thoracic ornamentation, in the larger seventh segment of the female abdomen, and in the straighter and nearly cylindrical male claspers.

Aëdes (Ochlerotatus) ashworthi, sp. nov.

Head clothed at the sides with broad flat whitish scales; in the middle of vertex with loosely applied narrower flat straight scales; on the nape with quite narrow curved scales; bristles black. Proboscis dark-scaled, slender, nearly one-half longer than the front femora. Palpi dark-scaled; in the female nearly one-fourth as long as the proboscis, the second joint swollen and longer than the first; in the male about four-fifths as long as the proboscis, long joint almost divided in the middle, equal in length to the last two joints together, tip of long joint and whole of penultimate joint with long dark hair, terminal joint very broad, slightly shorter than penultimate, nearly bare. *Thorax*: Integument of mesonotum dark brown, with large pale humeral patches, and traces of three blackish longitudinal lines; mesonotal scales all narrow, mostly ochreous, with some black ones intermixed. Pleurae with some flat, dull whitish scales. *Abdomen* brown, a broad band of dull grey scales at the base of each segment. Seventh segment of female large; eighth sternite also rather large and prominent; cerci very small, not longer than broad. *Male hypopygium*: Lobes of ninth tergite clothed with short hairs. Side-pieces about 3·5 times as long as broad, the lower flap without lobes, but bearing on its edge a row of peculiar bristles which are flattened towards the tips, almost club-shaped, these bristles extending for more than two-thirds of the distance from the base of the side-piece. Claspette represented by a small basal lobe of the upper flap of the side-piece, this lobe truncating apically and bearing about a dozen rather long twisted scales or flattened bristles. Claspers long, nearly cylindrical, gradually narrowed and somewhat curved on the apical half, with a moderately long terminal spine. Mesosome rather short and broad, simple. *Legs* dark, except for the whitish undersides of the femora and the narrowly ochreous tips

of the femora and tibiae. Claw formula: ♂ 2 : 1. 2 : 1. 1 : 1; ♀ 1 : 1. 1 : 1. 1 : 1. *Wings* entirely brown-scaled; scales of the lateral series long, linear; those of the median series also rather long. Cell R_2 over twice as long as its stem in the female, its base slightly proximal to that of cell M_1. Wing-length 4–4·5 mm.

Larva: Head rather broad for this group; clypeal hairs all simple. Antennae moderately long, slightly curved, almost cylindrical and nearly bare; a single hair just beyond the middle. Comb of eighth abdominal segment consisting of a triangular patch of 50 or more pointed scales. Siphon about three times as long as its greatest breadth, slightly contracted at base and tip, not very strongly chitinised. Pecten short, consisting of about 12 (fewer in the younger larvae) sharp-pointed, simple teeth, placed so close together that their bases touch; the first of these teeth is situated at about one-fifth of the length of the siphon, but in some specimens the actual pecten is preceded by one or two small, widely-spaced, simple bristles. Hair-tuft of about eight hairs, situated a little beyond middle of siphon. Tracheal tubes very large, strongly chitinised, occupying almost the whole of the middle part of the siphon, but strongly and abruptly contracted before the base of the latter. Anal segment with a lightly chitinised saddle; gills very small and globular. Brush well-developed, with 10–12 elements.

West Australia: Yallingup, ix.1914 (*Dr. J. H. Ashworth*). Type and one other male, one female, and a dozen larvae presented to the British Museum by the Imperial Bureau of Entomology in 1915.

This species is nearly allied to *O. crucians*, Walker (*tasmaniensis*, Strickland), and *O.* (*Caenocephalus*) *concolor*, Taylor, differing from both chiefly in the details of the hypopygium. *O. crucians* has the clasper very much swollen in the middle, its terminal spine shorter and stouter, and the flattened bristles on the margin of the side-pieces much less numerous; the terminal joint of the male palpi is much more slender. Probably the specimens of *O. concolor* from Tasmania recorded by Taylor are really *O. crucians*; the true *O. concolor* from New South Wales (which was wrongly described as having simple female claws) resembles *O. crucians* in its hypopygium, but the claspers are less swollen, the scales on the claspette lobes are less numerous, and the last joint of the male palpi is swollen, as in *O. ashworthi*. Doubtless the three forms are geographical representatives of the same type.

Aëdes (?Skusea) funerea, Theobald.

A male and female, apparently of this species, have been received from Dr. Swellengrebel, from Amboina. No Australian male is available for comparison, and the identification is therefore not absolutely certain, though probably correct. The male hypopygium of the Amboina specimen does not show the least resemblance to *S. pembaensis*, but, on the other hand, resembles that of *Aëdes panayensis*, Ludlow; from this it differs in the absence of a long process at the base of the side-piece, and in the presence of a short spine instead of a thick projection at the tip of the side-piece. Probably the species would be better placed in the subgenus *Aëdes* than in *Skusea*, but much more knowledge of the biology of these forms is necessary before their classification can be regarded as satisfactory.

Aëdes (?Skusea) funerea var. **ornata,** Theobald.

Lepidotomyia lineata, Taylor, Trans. Ent. Soc., 1914, p. 191 (1914).

A male and female have been received from Dr. Swellengrebel from Ceram. The male hypopygium is identical with that of *S. funerea* from Amboina, and the form is therefore probably correctly regarded as merely a variety of *S. funerea*, in spite of the striking difference in thoracic ornamentation. Two female paratypes of *L. lineata*, sent by Mr. G. F. Hill, agree with the female from Ceram.

Aëdes (Skusea) punctipes, sp. nov.

♀. *Head* entirely clothed with rather close-lying, flat blunt-ended scales; on the upper surface three black patches alternate with four white ones, black scales occurring again low down at the sides. Eyes separated by a rather narrow white-scaled line. Proboscis dark-scaled, not swollen at the tip, equal in length to the front femora. Palpi dark-scaled, rather more than a quarter as long as the proboscis. Antennae missing. *Thorax*: Prothoracic lobes and pro-epimera with rather broad white scales; mesonotum with narrow curved white scales round the front margin, narrow light bronzy-brown scales rather densely covering the rest of the surface; these scales are somewhat broader and denser on the posterior portion of the mesonotum, while on the space in front of the scutellum, which is normally bare, as well as on the scutellum itself, are broad flat blackish-brown scales; a small patch of similar scales above the root of each wing. Postnotum bare. Pleurae with patches of flat white scales. Mesonotal bristles mostly denuded, probably rather long and dense. *Abdomen* brown-scaled above, except the first tergite, which has creamy scales; tergites 2–7 have lateral white spots, which are not quite basal in position and extend a short way on to the dorsal surface. Venter mostly pale, apical sternites dark-scaled apically. The eighth segment and cerci are not visible externally; sixth and seventh sternites prominent in side view. *Legs* mostly brown-scaled; femora lighter beneath, and with a distinct whitish preapical ring; extreme tips of femora and tibiae also whitish. Front tibiae with three, middle and hind tibiae with four small, but distinct, whitish spots on the anterior surface. First joint of all tarsi with a narrow white ring at the base; junction of first and second joints with a small white dorsal spot; first mid-tarsal joint also with a median dorsal white spot, which on the hind legs becomes a complete narrow white ring; second hind tarsal joint narrowly white at the tip. Tibial bristles short, pale. Mid and hind tibiae equal in length. First tarsal joint on front legs about half as long as the tibia, and distinctly shorter than the remaining joints together; on hind legs about two-thirds as long as the tibia. Claws simple. *Wings* brown-scaled, except for the base of the fifth longitudinal vein, which is white. Scales all rather long and broad, mostly obliquely truncate at the tips; only a few longer and narrower ones towards the tips of the veins and along the lower margin of the upper branch of the fifth vein. Wing-fringe very long. Upper fork-cell fully twice as long as its stem, and with its base nearer the base of the wing than that of the lower.

UPPER BURMA: Maymyo, xi–xii.1913 (*Major Bennett*), 1 ♀.

Type in the Indian Museum.

A very distinct species, easily recognised by the leg markings and thoracic scaling. The structure of the abdomen and claws shows that it is quite closely related to *Stegomyia periskeleta*, Giles (=*Ochlerotatus annulifemur*, Edw.), and *S. microptera*, Giles. Both these species have male palpi of the *Ochlerotatus* rather than of the *Stegomyia* type, and, on the other hand, show some relation to *Armigeres* in the structure of the mesosome of the aedeagus. The type species of *Skusea* (*S. pembaensis*, Theo.), though with very dissimilar hypopygium, agrees with these Oriental species in general appearance and in the structure of the male palpi and female abdomen and claws, and all four are probably best relegated to the same genus or subgenus of the *Aëdes* group. The new species, like its ally *S. microptera*, may be expected to be a tree-breeder. It is in such habitats that the species showing the most striking variations from the normal type of Aëdine structure are found, sometimes, as in the present instance, indicating connections with other groups.

Culex crinicauda, nom. nov.

Culex parvus, Taylor, Bull. N. Terr. Austral., 1a, p. 27 (1912); nec *Culex parvus*, Macquart.

Although my suggestion that this might be synonymous with *C. vishuni*, Theo., was adopted by Taylor, such is, nevertheless, not the case. The hypopygium of a

male determined by Taylor and sent by Mr. G. F. Hill is very different from that of *C. vishnui*, and shows some peculiar characters. The clasper is unusually broad, almost straight, and has round its base a rather dense tuft of hairs. The lobe of the side-piece bears the usual leaf and filaments, but the filament adjacent to the leaf is remarkably long, flattened, and backwardly (caudally) directed.

Culex taylori, nom. nov.

Leucomyia annulirostris, Taylor, Trans. Ent. Soc. 1913, p. 696 (1914); nec *Culex annulirostris*, Skuse.

A male paratype has been received from Mr. G. F. Hill. The species appears to be a distinct one, allied, as Taylor stated, to *C. sinensis*, Theo., but differing in having the pale bands of the abdomen confined to the bases of most of the segments, and without pale spotting on the tibiae. From *C. sitiens* it differs in the much broader pale apex to the last palpal joint.

Culex basicinctus, nom. nov.*

Leucomyia annulata, Taylor, Trans. Ent. Soc. 1913, p. 695 (1914); nec *Culex annulatus*, Schrank.

Two males and three females have been received from Mr. G. F. Hill, collected by him at Townsville. They were sent as *Leucomyia annulirostris*, but agree with Taylor's description of *L. annulata*, and are almost certainly that species. *C. basicinctus* seems nearly allied to *C. whitmorei*, Giles, and, like that species, has the pale rings of the tarsi confined to the bases of the joints, and the pale bands of the abdomen angularly produced in the middle; it differs obviously in many points, *e.g.*, its larger size, duller thoracic colouring, and broader white tip to the last joint of the male palpi. A peculiar character, not mentioned by Taylor, is that the male palpi have two black bristles at the extreme tip, which are conspicuous against the adjacent white hairs.

Culex ventrilloni, Edw.

Culex ventrilloni, Edwards, Bull. Ent. Res. xi, p. 135 (Sept. 1920).

Culex albigenu, Enderlein, Wien. Ent. Zeitschr. xxxviii, p. 50 (Nov. 1920).

A male of *C. albigenu* lent me by Dr. Enderlein enables me to state the above synonymy. Somewhat unexpectedly, the species proves to be a true *Culex*, in Dyar's most restricted sense; the hypopygium has almost the same structure as in the African *C. simpsoni*, Theo., and *C. andersoni*, Edw.

Culex quasigelidus, Theo.

Culex auritaenia, Enderlein, Wien. Ent. Zeitschr. xxxviii, p. 49 (Nov. 1920).

The above synonymy, evident from the description, is confirmed by the examination of specimens sent by Dr. Enderlein.

Culex (Lophoceratomyia) jenseni (Meij.).

Cyathomyia jenseni, de Meijere, Ann. Jard. Bot. Buitenzorg, (2) iii, p. 922 (1910).

Lophoceratomyia curtipalpis, Edwards, Bull. Ent. Res. v, p. 127 (1914).

The above synonymy is proved by comparison of the type of *L. curtipalpis* with a paratype of *C. jenseni*, presented to the British Museum by Professor de Meijere. The species is wrongly placed in my table of the species of this subgenus (Bull. Ent. Res. vii, p. 227, 1917); it should come under heading 9, differing from the other species there included in the shorter male palpi.

* [There does not appear to be any reasonable ground for proposing this new name. Schrank's species was transferred to *Theobaldia* long before *Leucomyia annulata* was described, and there can be no possibility of confusion between them.—Ed.]

My previous use of the name *Cyathomyia* in the sense of *Protomelanoconion*, Theobald, proves therefore to be erroneous; if the group is retained as a distinct subgenus of *Culex*, Theobald's name will have to be revived, *Cyathomyia* falling as a synonym of *Lophoceratomyia*. However, *C. brevipalpis*, Giles, and *P. fuscum*, Theo., have a hypopygium constructed much as in *Neoculex*, Dyar, and should probably be referred to that subgenus.

Rachisoura filipes (Walker).

Culex filipes, Walker, Proc. Linn. Soc. v, p. 229 (1861).

Rachisoura sylvestris, Theobald, Mon. Cul. v, p. 208 (1910).

Stegomyia hilli, Taylor, Proc. Linn. Soc. N.S.W. xxxix, p. 456 (1914).

Mimeteomyia hilli, Taylor, Proc. Linn. Soc. N.S.W. xli, p. 566 (1916).

The above synonymy appears to be proved by a comparison of Walker's and Theobald's types with a specimen of *S. hilli* from Stapleton, Northern Territory, sent by Mr. G. F. Hill. The genera *Rachisoura* and *Mimeteomyia* are probably not distinguishable; they differ from *Rachionotomyia* in the shorter and stouter proboscis, which is little, if any, longer than the front femora.

Rachionotomyia aenea, sp. nov. ♀.

Head dark-scaled, with a moderately broad pale band in front, which is blue or whitish according to the direction of the light. Palpi and proboscis purplish-scaled, the palpi exceeding the clypeus by about twice the length of the latter. Antennal torus orange. *Thorax* with the integument orange-brown, darker brown on the mesonotum. Prothoracic lobes with black bristles and narrow, almost hair-like, dark brown scales. Mesonotum with narrow dark brown scales, except on, and just in front of, the scutellum and between the scutellum and the wing-bases, where the scales are broad, flat and bronzy-green in colour. Pleurae with a large silver-scaled dark brown patch. *Abdomen* purplish-black above, golden beneath, the tergites with lateral subapical bluish-silvery patches. *Legs* purplish-scaled; middle femora in front with a silvery streak on the basal half and a silvery subapical spot; front and hind femora unmarked. *Wings* with dark brown scales; those on the fork-cells short and rather broad. Upper fork-cell slightly longer than its stalk, its base distinctly distal to that of the lower. Cross-veins separated by more than the length of the posterior. Wing-length 3 mm.

Malay States: Edges of stream, Ampang jungle, Kuala Lumpur, 21.v.1904 (*Dr. G. F. Leicester*), 1 ♀.

Allied most nearly to *R. similis*, Leicester, differing in the unspotted front and hind femora, and in some other points.

Rachionotomyia purpurata, sp. nov. ♀.

Nearly allied to *R. bimaculipes* (Theobald), differing as follows:—Integument of mesonotum orange, almost dull (instead of shining blackish), clothed with narrow greenish scales mixed with some black ones; pro-epimera with small flat black scales (bare, perhaps rubbed, in *R. bimaculipes*); dark scales of abdomen with strong purple reflections (instead of dull black).

Fiji Is.: Suva, 10.iv.1911, 3 ♀ reared from larvae (*Dr. P. H. Bahr*, pres. by *Lt.-Col. A. Alcock*).

Rachionotomyia quasiornata (Taylor).

Stegomyia quasiornata, Taylor, Proc. Linn. Soc. N.S.W. xl, p. 177 (1915).

This is very similar to *R. bimaculipes* and *R. purpurata*, but differs from both in having narrow instead of broad and flat scales on the prothoracic lobes. A female has recently been received through the Imperial Bureau of Entomology, named by Mr. G. F. Hill after comparison with Taylor's type; it shows the long proboscis characteristic of the genus. In all these three Australasian species the palpi are shorter than in the Oriental forms, exceeding the clypeus by hardly more than the length of the latter.

BIOLOGICAL STUDIES OF APHIS RUMICIS, LINN.*

By J. Davidson, D.Sc.

The Entomological Department, Institute of Plant Pathology, Rothamsted Experimental Station, Harpenden.

This is the first of a series of papers based on results of breeding experiments and on observations in the field. It is hoped that a full investigation of the biology of this species will be of value in elucidating the many difficult biological problems of the Aphididae.

The preliminary paper published by the author (1914) was to have been followed by further investigations, but owing to the outbreak of the European War there has been an unavoidable delay. However, experiments are now being continued, and the results of the researches will be published in parts from time to time.

As there is no complete description of *Aphis rumicis* in the literature, it is thought very desirable that a detailed illustrated description of all forms of this species should be given.

The following abbreviations are used in the text :—a.v. ♀ = apterous viviparous female ; w.v. ♀ = winged viviparous female ; 1st v. gen. = 1st, 2nd, etc., viviparous generation.

I. Description of Aphis rumicis, Linn.

1. Fundatrix (fig. 1). Average size, 1·8 mm. by 1·4 mm.†

Body oval to elongate, broadly rounded posteriorly, shorter and relatively stouter than the succeeding a.v. ♀ ♀; colour black to dark green ; hairs scattered over the body.

Head : A few scattered hairs on dorsal surface. Eyes black ; small tubercle-like accessory eyes‡ on posterior margin. Antennae§ about two-thirds length of body ; black to dark brown, paler about the middle ; five segments ; seg. 3 the longest ; 1 slightly broader than long ; 2 slightly longer than broad, subequal in length ; 4 shorter than 5 ; 5 almost as long as 3 ; a single subapical sensorium on seg. 4 and a compound sensorium on seg. 5 ; a few short hairs on each segment. Rostrum normal, with a few hairs on each segment.

Thorax : A pair of prominent lateral tubercles on prothorax. Legs black, with tibiae and proximal portions of femora paler ; segments bearing many short hairs, especially the tibiae.

Abdomen with two prominent lateral tubercles on each side. Cornicles black to dark brown, imbricated, tubular, tapering very slightly distally, shorter than in succeeding a.v. ♀ ♀ ; about one and one-third times the length of cauda as seen from the dorsum. Cauda short, bluntly rounded, black on distal portion ; bearing several long curved hairs. Anal plate black, roughly quadrangular as seen from venter, bearing a number of short hairs, anterior margin more or less straight. Genital plate black, somewhat crescentic in shape, with outer margins rounded ; bearing a number of stout hairs and short spines.

* This species is the black aphis found in spring on the spindle tree (*Euonymus europaeus*), and later on beans, poppies, and many other plants. It has many synonyms, owing to its polyphagous habits, but the name given by Linnaeus in 1746 holds priority. The more important synonyms are *Aphis papaveris*, Fabr. ; *Aphis euonymi*, Fabr. ; and *Aphis fabae*, Scop. For other synonyms see Theobald, 1912.

† The measurements given are total length of body excluding the cauda, and the greatest width of the abdomen. The size is very variable, depending largely on food and temperature conditions.

‡ Accessory eyes (Berlese, "Gli Insetti") ; ocular tubercles (Baker, 1920).

§ The "unguis" (Baker, 1920), or "processus terminalis" (Tullgren, 1909), of the terminal segment is here considered as being part of the distal segment.

First Larval Instar has 4-segmented antennae, with sensorium on segs. 4 and 5; tubercle-like cornicles; small obtuse cauda and stout legs.

Second Larval Instar has 5-segmented antennae.

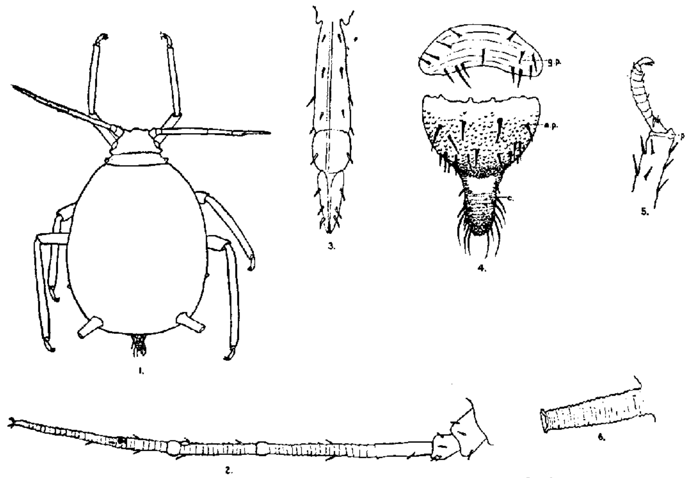


Fig. 1. *Aphis rumicis*, Linn., fundatrix: (1) dorsal view; (2) antenna; (3) rostrum; (4) posterior end of venter, *a.p.*, anal plate, *g.p.*, genital plate, *c*, cauda; (5) tarsus of third leg, *p*, empodium or pad; (6) cornicle.

2. Apterous Viviparous Female (fig. 2). Average size 2·5 mm. by 1·6 mm. *Body* elongate oval; colour variable, black to olive-green, often with irregular darker pigmented areas over the abdomen; small hairs scattered over the body.

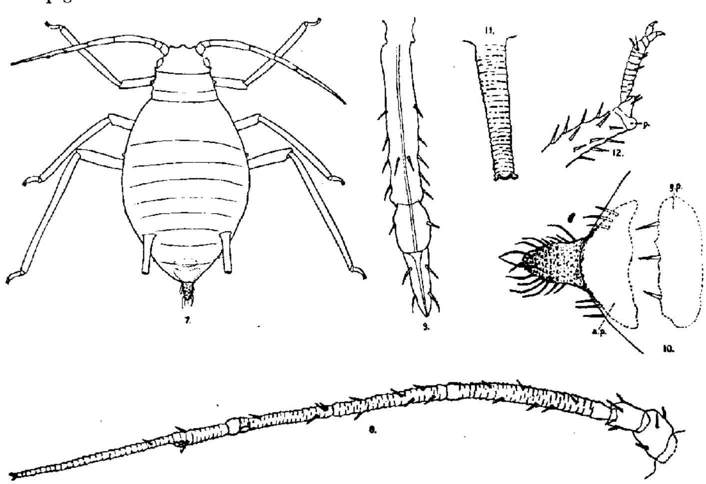


Fig. 2. *Aphis rumicis*, Linn., apterous viviparous ♀: (7) dorsal view; (8) antenna; (9) rostrum; (10) cauda, dorsal view, *a.p.*, anal plate, *g.p.*, genital plate; (11) cornicle; (12) tarsus of third leg, *p*, empodium.

Head: Eyes black, with prominent accessory eyes. Antennae six-jointed; seg. 1, apical portion of seg. 5 and proximal portion of seg. 6 black, remainder of a paler colour; seg. 6 (including processus terminalis) the longest, about equal to 4 and 5 together; 3 about three-fourths the length of 6, longer than 4; 4 slightly longer than 5; 1 and 2 subequal in length; a single subapical sensorium on seg. 5; a compound sensorium on seg. 6; a few hairs on all segments. Rostrum normal, with a few hairs on the segments.

Thorax with a prominent prothoracic tubercle on each side. Legs black; tibiae and proximal portion of femora paler; segments bearing stout hairs, especially the tibiae.

Abdomen with two lateral tubercles on each side and sometimes one or two small indefinite tubercles. Cornicles black, tubular, imbricated, slightly tapering distally, varying in length, but usually about one and one-third to one and one-half times the length of the cauda as viewed from dorsum. Cauda with distal half slightly spoon-shaped, black, clothed with short stout bristles and several long curved hairs. Anal and genital plates as in fundatrix.

3. Winged Viviparous Female (fig. 3). Average size, 2·4 mm. by 1·3 mm.

Body: Head and thorax black to brownish black; the abdomen varying from dirty brownish black to olive-green, usually with irregular darker pigmented areas on the abdomen. Small hairs scattered over the body.

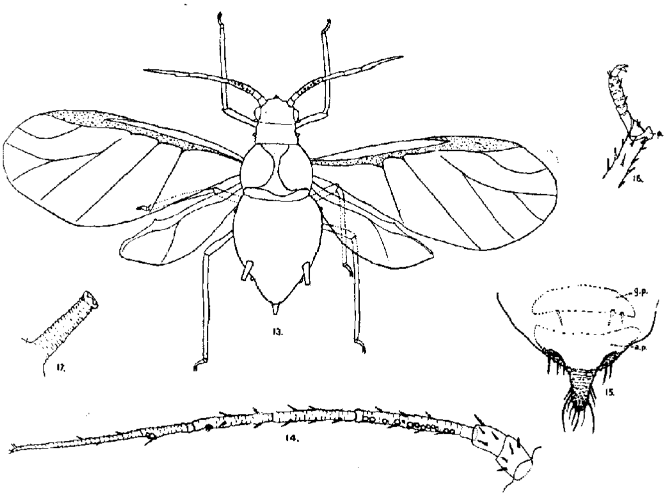


Fig. 3. *Aphis rumicis*, winged viviparous ♀: (13) dorsal view; (14) antenna; (15) cauda, dorsal view, *a.p.*, anal plate, *g.p.*, genital plate; (16) tarsus of third leg, *p*, empodium or pad; (17) cornicle.

Head black. Eyes black, with prominent accessory eyes. Antennae dirty brown to black, varying in length, about two-third length of body; seg. 3 slightly longer than 4; seg. 4 slightly longer than 5; 1 and 2 subequal; subapical sensorium on seg. 5, and a compound sensorium on seg. 6; a varying number of about 12–18 subcircular sensoria distributed over seg. 3 and none or 1–4 over seg. 4; segments 3 to 6 imbricated. Rostrum dark towards distal end; normal.

(2416)

Thorax with two prominent lateral tubercles on prothorax. Wings normal. Legs somewhat longer than in a.v. ♀, otherwise similar.

Abdomen varying in colour from dark velvet-black to olive-green, usually with five irregular pigmented areas along the lateral dorsal area and irregular transverse areas segmentally arranged; lateral tubercles prominent. Cornicles black, varying in length, usually about one and one-half times length of cauda as viewed from dorsum, imbricate, tubular, slightly tapering distally. Cauda not so large as in a.v. ♀, otherwise similar. Anal and genital plates as in a.v. ♀.

4. SEXUPARAE.

(*a*). Male-producing sexuparae, apterous, resembling apterous viviparous female.

(*b*). Female-producing sexuparae, winged, resembling winged viviparous female, but somewhat larger in size.

5. MALE (fig. 4). Average size, 1·4 mm. by 0·7 mm.

Body smaller than in w.v. ♀, narrower and more tapering distally; seen from dorsum it appears to be shining black, but the abdomen is often very dark green; small hairs scattered over the body.

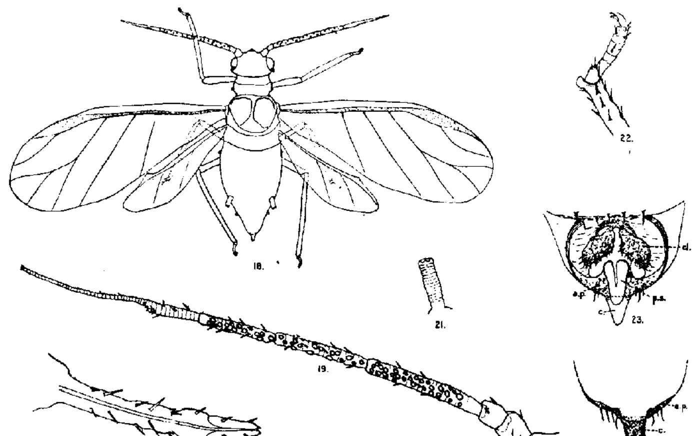


Fig. 4. *Aphis rumicis*, ♂: (18) dorsal view; (19) antenna; (20) rostrum; (21) cornicle; (22) tarsus of third leg; (23) posterior end of venter, showing genital armature, *a.p.*, anal plate, *c*, cauda, *cl.*, claspers, *p.s.*, penis sheath; (24) cauda, dorsal view.

Head black. Eyes large, black; accessory eyes prominent. Antennae about two-third to three-quarters length of body, black, but sometimes paler; segments 1 and 2 subequal; 3 shorter than 6; 4 slightly shorter than 3; numerous subcircular sensoria on segments 3, 4 and 5, and a compound sensorium on 6; a few hairs on all segments. Rostrum normal.

Thorax black and shining; prothoracic tubercles prominent. Legs slender, black, with greater part of tibiae and femora paler; hairs on all segments, especially tibiae.

Abdomen varying, almost black to dark green, black along lateral margins, irregular patches of darker pigmented areas more or less segmentally arranged; two lateral

tubercles present on each side. Cornicles dark to black, short, small, tubular, imbricated, a little longer than the cauda viewed from the dorsum. Cauda smaller than in w.v. ♀; covered with short spines and several long hairs; distal portion black. Anal plate black. Genital plate black, bearing two dark claspers (gonapophyses) clothed with spines and stout hairs. Penis sheath paler.

6. OVIPAROUS FEMALE (fig. 5). Average size, 1–6 mm. by 0·9 mm.

Body small and narrow compared with the a.v. ♀, tapering posteriorly; dirty brownish black to dark green in colour, often of a dark green velvety appearance; short hairs distributed over the body.

Head black to dark green. Eyes small, black; accessory eyes small. Antennae about two-thirds length of body; pale dirty grey, segments 1 and 2 and distal portion of 4 and 5 darker; seg. 6 about equal in length to 3, 4 and 5 together; 3 longer than 4 or 5; 4 slightly shorter than 5; a compound sensorium on seg. 6 and a subapical sensorium on 5; a few hairs over each segment. Rostrum normal, dark on distal portion, with fewer hairs on the segments.

Thorax with lateral tubercles on prothorax prominent. Legs relatively short and stout; of a dirty greyish colour, with coxae, trochanters and tarsi darker; hairs on all segments, especially on tibiae; tibiae of third pair of legs much swollen, and possessing numerous irregular roundish light-coloured areas (? sensoria) over the whole length.

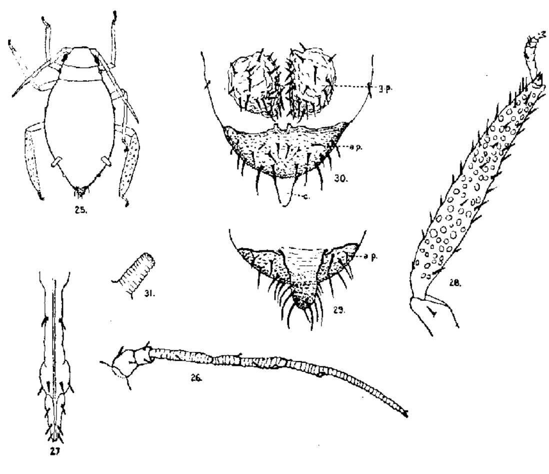


Fig. 5. *Aphis rumicis*, oviparous ♀: (25) dorsal view; (26) antenna; (27) rostrum; (28) tibia of third leg; (29) cauda, dorsal view; (30) posterior end of venter, *a.p.*, anal plate, *g.p.*, genital plate, *c*, cauda; (31) cornicle.

Abdomen dark green, with occasional lighter-coloured areas; two tubercles on each side. Cornicles quite small, black, imbricated, tubular, a little longer than the cauda as viewed from the dorsum. Cauda small but stout, black on distal portion. Anal plate black. Genital plate bilobed, black, and covered with long hairs.

Ova, when first laid, somewhat greenish, but rapidly becoming black and shiny on exposure to the air. Average size, 0·5 mm.

II. Life-History of Aphis rumicis.

The following account of the life-history of this species is based upon extensive breeding experiments and observations in the field. Experiments were carried on during 1913 and the early part of 1914, and continued during 1920.

The Aphids were reared from eggs on *Euonymus*, and transferred to broad beans as the summer host, the winged remigrantes or sexuparae of the later generations being transferred back to *Euonymus*. The plants were grown in pots in a large open glasshouse and kept covered with muslin bags, and observations on the different generations of the Aphids were periodically recorded. It is hardly practicable, for reasons of economy, to publish the observations made on the long series of plants infected, but the records of certain plants will be given in later sections of these biological studies. It is from the data derived from these observations, together with contemporary observations in the field, that the life-cycle has been worked out.

The ova hatch out in spring (March and April) on the winter host, *Euonymus europaeus*,* giving rise to the larvae of the fundatrices. In 8–10 days after birth, in favourable temperature conditions, the fundatrices become adult and begin to produce parthenogenetic viviparous young, which become adult about 10 days after birth. This is the first viviparous generation, and it may consist of a mixed progeny of both alate and apterous viviparous females, or of the latter only. The a.v. ♀♀ produce on *Euonymus* the second viviparous generation, which may consist of w.v. ♀♀ and a.v. ♀♀, the former being generally in the majority. The a.v. ♀♀ produce a further generation, consisting either entirely of w.v. ♀♀, or of a mixed progeny of w.v. ♀♀ and a.v. ♀♀, the w.v. ♀♀ being in the majority.

There is a tendency for the a.v. ♀♀ of these early generations on *Euonymus* to produce w.v. ♀♀ in the majority. These w.v. ♀♀ are the winged migrants from the winter host to the intermediate or summer hosts, such as beans, poppies, etc. It is owing to this tendency that the a.v. ♀♀ on *Euonymus* eventually die out, and as the season advances the tree becomes free from the aphis. Some of the w.v. ♀♀ may in some cases remain a short time on *Euonymus* and produce young on it, but owing to the innate desire of the winged forms to migrate (a marked feature of the winged forms when the Aphids are reared in captivity), they soon leave the *Euonymus* and fly to the intermediate hosts.

The generations of individuals from the fundatrices on *Euonymus* are the fundatrigeniae, the a.v. ♀♀ being the fundatrigeniae apterae and the w.v. ♀♀ the fundatrigeniae alatae. These latter are the winged migrants (migrantes), which fly to the intermediate hosts, being the mothers of the succeeding viviparous generations. The generations of individuals from the migrantes on the intermediate hosts are called the alienicolae, the a.v. ♀♀ being the alienicolae apterae, and the w.v. ♀♀ the alienicolae alatae.

The intermediate hosts are numerous, but of the cultivated plants beans are specially favourable, and afford the best stimulus to rapid reproduction. The migrantes give rise to the first viviparous generation on the intermediate host, the individuals of which are a.v. ♀♀. These produce a further generation, which may consist of a.v. ♀♀ or a mixed progeny of w.v. ♀♀ and a.v. ♀♀. The former may remain a little time on the same plant and produce young, or may fly to other plants, either of the same kind or other hosts, and produce a further generation. My experiments show that the tendency is for w.v. ♀♀ to produce a.v. ♀♀, and for a.v. ♀♀ to produce either a.v. ♀♀ or a mixed progeny with a varying percentage of w.v. ♀♀. This would

* The spindle-tree is undoubtedly a winter host of *Aphis rumicis*, but considering the local distribution of *Euonymus* in Britain, it is highly probable that there are other winter hosts. Gaumont (1913) found all stages on *E. japonicus*. Mordwilko (1907) found *Aphis euonymi* in spring on *Viburnum opulus* at Bjelovesh. It was also found on *Viburnum opulus* by Kaltenbach (*Aphis euonymi*) and by Passerini (*Aphis papaveris*). It is evident that further research is greatly needed in order to ascertain the common winter hosts of this abundant Aphid.

appear to be an adaptation of the species to its polyphagous habits. Thus when the w.v. ♀♀ alight on a new plant a good colony is established on that plant by a.v. ♀♀ being produced. On the other hand, the liability to overcrowding as the plant becomes heavily infested is overcome, and the wider distribution of the species to other host-plants is ensured by the production of winged forms in due course.

Towards the end of summer, after a number of agamic generations have been passed through on the intermediate hosts and at a time when suitable intermediate hosts are becoming scarce, there are produced winged viviparous females, which are physiologically specialised, but morphologically resemble the other alienicolae alatae. These are the sexuparae alatae or remigrantes. They fly back to the winter host, on which they produce true oviparous ♀♀.

At about the same period winged ♂♂ are produced from certain of the alienicolae apterae (sexuparae apterae) on the intermediate hosts and fly to the winter host, where the sexual ♀♀ are fertilised. Fertilised eggs are then laid on the winter host, near the buds, or in crevices in the bark of the older branches. These over-winter and hatch out in spring, producing the fundatrices.

The alienicolae apterae on the intermediate hosts gradually die out, owing partly to the tendency to produce w.v. ♀♀ or winged sexuparae and ♂♂, and partly to unfavourable conditions.* By confining the Aphids to broad bean plants, sexual forms were produced on these plants in due course.†

In my experiments it was found that the alienicolae alatae of any generation could be transferred back to *Euonymus*, on which plant they produced young, and eventually in succeeding generations both sexual ♂♂ and sexual ♀♀ appeared. Further, it was found that even if the Aphids are bred in successive generations on *Euonymus*, sexual ♂♂ and ♀♀ will appear in due course. It should be noted, however, that young growth was ensured on the *Euonymus* bushes by cutting them back. Males were first noted on 10th August 1920.

Similarly on beans, on which intermediate host the Aphids were bred continuously from May, several ♂♂ appeared in due course, and in some cases oviparous ♀♀ were also found. The ♂♂ are produced by alienicolae apterae toward the end of summer on the intermediate host-plants, and the oviparous ♀♀ by the physiologically specialised alienicolae alatae (sexuparae alatae) on the winter host, at about the same time. The male-producing sexuparae are thus a.v. ♀♀. One and the same mother may produce sexual males and sexuparae alatae, but the sexuparae alatae only produce sexual females.

It seems evident that in the adventures of migration the alienicolae alatae of any generation may alight on the winter host (*Euonymus*) and produce young, resulting eventually in colonies consisting of all stages, namely, a.v. ♀♀, w.v. ♀♀, ♂♂ and ♀♀. Mordwilko (1907) found all stages on *Euonymus* in Warsaw at end of September 1894. He also found a colony of a.v. ♀♀ on *Viburnum opulus* in Warsaw at the end of September.

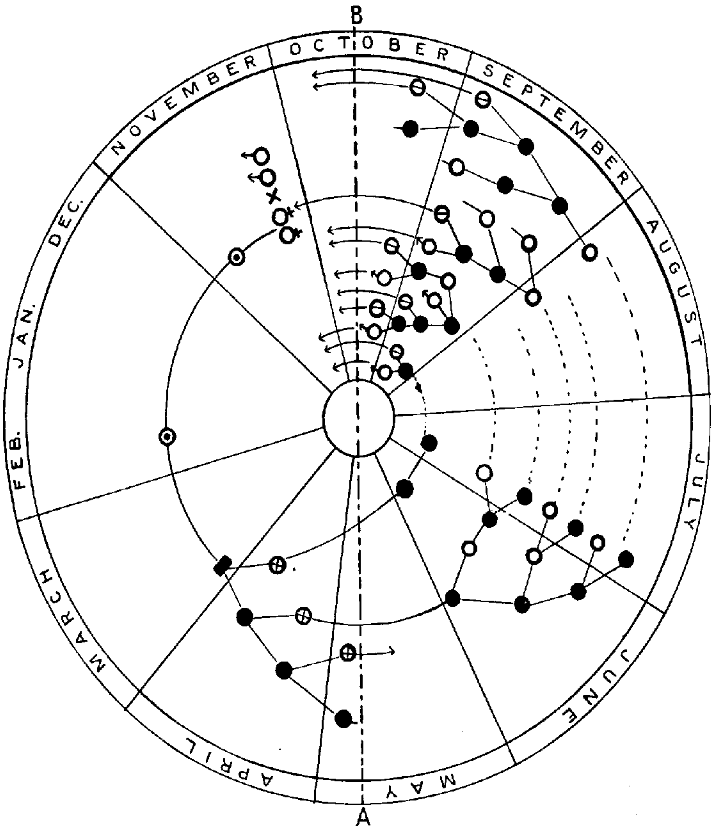
Similarly, sexuparae alatae alighting on intermediate host-plants may give rise to sexual ♀♀, which might thus be found together with colonies of agamic forms and sexual males. This would explain the finding by Theobald (1912) of sexual ♀♀ ovipositing on *Rumex*, by Gaumont (1913) on sugar-beet in October 1913, and by Malaquin and Moitié (1914) on haricot beans in October 1913.

* It seems probable that during a mild winter agamic forms may persist throughout on certain plants and carry on agamic reproduction normally in the following year. Davidson (1914) found a colony of apterous agamic females on 30th January 1913 on *Euonymus* at Richmond. The tree was taken into a greenhouse, and agamic reproduction was carried on normally throughout 1913. Several cases of long-continued parthenogenetic reproduction have been observed. The question will be discussed in a later section dealing with the appearance of sexual forms. It may be stated here that I have carried on a parthenogenetic strain throughout winter in a warm greenhouse, winged sexuparae (which produce sexual ♀♀), sexual ♂♂ and parthenogenetic a.v. ♀♀ being produced in each generation from September to May.

† Mordwilko (1907) was not able to obtain females on intermediate hosts.

During the autumn, when the intermediate hosts are mostly unfavourable for the Aphids, the winter hosts, such as *Euonymus,* offer the most favourable food conditions and the greatest chances of survival. From the nature of *Rumex* and other intermediate hosts under winter conditions and the difficulty in ensuring food for the young larvae immediately they hatch out from the eggs in spring, these cases, I think, must only be considered as casual winter hosts. The sexual forms may develop in several generations. In fact, in one series of experiments under favourable conditions of food and temperature, sexual forms appeared in five succeeding generations. Weather conditions and the dying down of the intermediate hosts are very important factors in limiting the length of period over which sexual forms are produced. These questions will be discussed more fully in a later section dealing with the appearance of the sexual forms.

The life-history of *Aphis rumicis* may be illustrated by the following diagram :—



⊙ = *Ova.* ▬ = *Fundatrices.* ● = *Apterous viviparous females.* ○ = *Winged viviparous females.*
⊗ = *Migrantes.* ⦶ = *Alate sexuparæ (Remigrantes).* ♂ = *Sexual males.* ♀ = *Oviparous females.*

Fig. 6. Diagram illustrating the life-cyle of *Aphis rumicis.* The line AB divides the circle into two halves, the winter host being represented on the left and the summer hosts on the right half; the sectors indicate the months, and the dotted concentric lines a varying number of generations occurring in July and August.

References.

DAVIDSON, J. (1914). Ann. Appl. Biol. i, pp. 118–141.
GAUMONT, M. L. (1913). C.R. Acad. Sci. Paris, clvii, pp. 1092–1094.
LINNAEUS, CAROLUS (1746). Fauna Suecica, p. 258, No. 979.
MORDWILKO, A. (1907). Biol. Centralb. xxvii, p. 529 *et seq.*
THEOBALD, F. V. (1912). Journ. Bd. Agric. xix, pp. 466–476.

THE NATURE AND FUNCTION OF THE CAUDAL TUFTS OF MALAYAN ANOPHELINE LARVAE.

By W. A. LAMBORN,
Malaria Bureau, Federated Malay States.

It has been found difficult to understand how such a fragile creature as an Anopheline larva could withstand the force of a strong current of water. In the following article it is proposed to explain the phenomenon on anatomical grounds.

The writer's previous experiences in Central Africa, where the seasons are far more definite than in the Federated Malay States, had shown that in the dry period, when there is often an entire absence of other possible breeding-places, the larvae of Anophelines are to be found in among the vegetation fringing the banks of the great rivers; hence, for instance, the notoriety as regards malaria of the whole extent of the Shire valley, in Nyasaland.

It was decided in June 1920 to make a tentative examination for larvae of the Klang River and its affluents in the vicinity of Kuala Lumpur, F.M.S., though there was not at that time any great expectation of being successful in the search. It is true that Dr. Hacker had in 1918 demonstrated the presence there of the larvae of *A. maculatus*, Theo., and *A. aconitus*, Dön.; but apart from the numerous breeding-places afforded elsewhere, swamps, grassy pools, muddy pools, drains, and excavations of various sorts, the heavy rains at frequent intervals during the previous three months had ensured the flow of a volume of water so enormous and a current so swift as to make it appear impossible that an object so fragile as a mosquito larva could maintain itself therein.

A few Anopheline larvae—*A. subpictus*, Grassi, var. *vagus*, Dön. (*A. rossi*, Giles, var. *indefinitus*, Ludl.), *A. barbirostris*, Wulp., *A. hyrcanus*, Pall. (*A. sinensis*, Wied.), *A. aconitus*, Dön., *A. maculatus*, Theo., *A. leucosphyrus*, Dön.—were discovered, and even with the river running strongly, could constantly be found in among the stems of the reeds and long grass at its sides. At no time were they numerous, and careful and diligent search was necessary to obtain them in a rapid current. The significance of their presence would appear to lie, not in their numbers, but rather in their ability to maintain themselves in such a situation, from which in due course the adults can diffuse themselves over the surrounding country, selecting at will, possibly at another season, breeding-places more auspicious to the welfare of their larvae.

The question which then arose was: How do the larvae manage to maintain themselves without being swept away? For not only in the river, but in other running water are the larvae of certain species constantly to be found.

A. maculatus larvae, for instance, can invariably be found in a grassy drain beside a railway embankment just outside the town, in which a considerable volume of water is usually flowing. A few *A. karwari* larvae were once found by the writer at Sungei Besi, eight miles south of Kuala Lumpur, apparently quite at ease at the side of a pot-hole through which the water was literally rushing from a higher level. The larvae of *A. aitkeni*, James, almost invariably favour jungle streams.

Some observations made in this connection so long ago as 1911 by Dr. Malcolm Watson, and recorded in his book "The Prevention of Malaria in the Federated Malay States" (p. 105), are of no small interest. Dr. Watson expresses the opinion that the ova of *A. maculatus* (*wilmori*) are laid in the shallowest possible water, usually at the head of a ravine, and the paragraph discussing further the distribution of the larvae is as follows:—

"From these springs the larvae are carried down by the streams, but they cannot be entirely washed out even by the strongest currents or rains. I have found them in

a drain after a two-inch shower. I have watched them at play in a clear pool at the foot of a rock down which water was flowing with considerable force, since the rock sloped to the pool at an angle of forty-five and its face was a foot long. The current of water was still further increased in strength by the rock being funnel-shaped, and all the water coming down the face was gathered into a solid stream as it entered the pool. The larvae were playing not exactly like trout, head to stream, but were floating round in the current, and every now and then one would swim right into the stream, up it for a short distance, and then hang on the side of the apparently bare rock in the full strength of the current." Further on (p. 116) he remarks that "the larvae have the power of attaching themselves to objects."

Anopheline larvae, at all events such as live in moving water, do not, as a rule, go in search of food. They rest at one place, brushing constantly the minute particles carried past into their mouths, consuming such as they wish, and ejecting the rest. It is hardly to be expected that a larva undergoing extremely rapid growth and development, on what would appear to be a precarious method of obtaining food material, could afford to waste any of its energy through having to keep its position by strong and constant muscular effort. Some sort of mechanism involving a minimum expenditure of energy, and not a means similar to the muscular effort that enables a fish to remain at one spot in a stream, was to be looked for. This is found in the dorsal pair of tail fans, the true function of which is now pointed out for the first time, so far as the writer has been able to ascertain.

Patton and Cragg, in their "Text Book of Medical Entomology" (1913, p. 200), describing the ninth segment of an Anopheline larva, state that "the dorsal border is furnished with two pairs of long feathered hairs, which are directed backwards as a tail. The ventral surface bears two rows of feathered hairs arising in the middle line from an elongated and raised area of thick chitin. The two rows are set very close together, so that when examined in side view they appear as one, and hang down at a right angle to the long axis of the body as a sort of fin. Each hair is articulated into a little round pit in the chitinised area."

Giles in his work "Gnats or Mosquitos" (second edition, p. 46), describing the larva of a *Culex*, states that on the last segment, "on either side, but originating in front of the anal tubercles, are a pair of large dense tufts of compound hairs, which are employed in swimming in the same way as a fish's tail, and are so arranged as to form an expansion of similar shape." In his description of an Anopheline larva (p. 60) he states that "the last segment carries four anal tubercles, which, as well as the tail fans, are rather less developed than in *Culex*."

The American authors—Howard, Dyar and Knab—in their "Mosquitoes of North and Central America and the West Indies," do not give any special description of these tufts in Anopheline larvae.

From the foregoing it is evident that no structural differentiation of the two sets of brushes in larvae had been noted. In the larvae of Malayan Anophelines the ventral tufts are as described. But with an objective even of such low power as $\frac{2}{3}$ in. marked differences are to be seen in the dorsal group. For the purposes of description the larva of *A. maculatus* at its last moult may be taken as presenting appearances more or less typical of the majority (fig. 1). In this the dorsal aspect of the ninth segment is furnished at its extremity with two brush-like structures on either side, each just to the outer side of the mid line. The upper and more internal brush consists of a short plume of feathered hairs, which are straight, scanty, and on one side almost double the length of those on the other. Most of the hairs taper gradually and terminate in a sharp point, but one or two of the longer ones may show a terminal hooklet so small as to require a $\frac{1}{8}$ in. objective for its detection. The second structure, just to the lower and outer side of the former, consists of a leash of six stout bristles, five of which are unbranched. They are considerably longer than any in the other brush, there being a slight progressive increase in the length of each, so

that the longest is about a quarter as much again the length of the shortest. All are of about the same calibre, which is practically uniform from end to end, and each of the five is recurved at its extremity, so as to form a rounded hook. The sixth bristle differs from the other five in being considerably shorter and in bearing seven lateral filaments, all of similar calibre but of different lengths, the two longest showing hooks. Not one of the bristles is perfectly straight, each showing a curve first upwards and then gradually in the reverse direction, more sharply towards the extremity. The ventral brushes consist of separate tufts of feathered filaments, arranged fanwise,

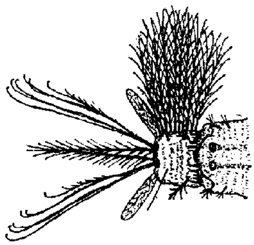


Fig. 1. Terminal segments of larva of *Anopheles maculatus*, Theo.

tapering gradually towards the extremity, which is pointed. They are apparently of less brittle material than the dorsal bristles; for whereas these often have the hooks broken off, or may be broken short when the larva has been much shaken about, the ventral filaments seem not to suffer such damage.

The hooked bristles are present throughout larval life. In the newly hatched larva there are two only on each side, and the number increases at each moult. The same structures are to be seen without any modification of form in the larvae of the following Anophelines:—*A. karwari*, *A. hyrcanus* (*sinensis*), *A. kochi*, *A. ludlowi*, Theo., and *A. subpictus* (*rossi*) and its var. *A. vagus* (*indefinitus*). In *A. fuliginosus*, Giles, *A. barbirostris*, *A. umbrosus*, Theo., *A. tessellatus*, Theo., and *A. aconitus*, there are, as a

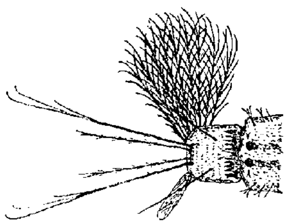


Fig. 2. Terminal segments of larva of *Anopheles asiaticus*, Theo.

rule, five main hooked bristles only; in *A. albotaeniatus*, Theo., var. *montanus*, Stant. & Hack., there are, as a rule, five, and the upper of the dorsal tufts shows considerable reduction in size. In the case of *A. aitkeni*, James, and *A. asiaticus*, Theo., there are marked differences; in *aitkeni* there are six main hooked bristles, one of which shows a branch almost as long as itself and also hooked, so making an additional main limb; moreover, the upper of the two dorsal tufts shows many more fine hooks at the extremities of the constituent hairs than in other species, doubtless an adaptation to its mode of life, the species breeding in mountain streams; in *asiaticus* (fig. 2) there are only two, or sometimes three, hooked bristles, which are

attenuated as in *Culex* and often crooked, and show hooks so diminutive as to make the determination of their presence difficult. In this also the upper of the dorsal tufts is reduced to a mere bristle clothed with a few sparse hairs.

It was of interest to learn from Col. Alcock, of the London School of Tropical Medicine, that these structures are present also in two of the British species, and that in the third, breeding in situations comparable with those favoured by *A. asiaticus* in the Federated Malay States, they are, as in that species, absent. The paragraph in his letter, dated 10th August 1920, which he has kindly allowed me to quote, is as follows :—

" On looking at the larvae of the three British species (after reading your letter), I find it to be as you describe in *A. maculipennis* and in *A. bifurcatus*, but not in *A. plumbeus*, that breeds in holes of trees. Now I understand how the larvae of the former two species anchor themselves at right angles to the sides of the aquarium."

Were these structures used for swimming, one would expect to find them at their maximum development in larvae which move more actively than most Anophelines in search of food, but this is not the case. *Stegomyia* probably owe their success as a race of mosquitos, not merely to their being able to breed in almost any situation invariably in stagnant water in which insect enemies are commonly absent, but to the activity they are able to develop in their search, both at the surface and at a depth, for the scanty and miscellaneous food material such places often afford. Placed in a bowl, they may be seen moving constantly, head down, over any surface on which food material may be obtained ; they never remain passive at the side, content to take such food as comes along, as some Anopheline larvae do. In these larvae the various caudal structures are least developed, being represented by a much simpler arrangement of hairs. There are in the last ecdysis three dorsal and three ventral hairs only on each side, all relatively longer than in Anophelines (except in *A. asiaticus*), perfectly straight and tapering gradually so as to end in a fine needle-point.

Anopheles larvae may be called on at times to make a sudden and very rapid movement ; this is essential to enable them to escape their enemies, and it is effected by all these larvae, which swim backwards, at all events when on the surface of the water, by sudden contractions of the body, as in the case of *Stegomyia*. But it is essential for such as live in moving water that the movements should be to some extent objective, towards some support, so that they may avoid being swept away. It is suggested that direction is attained by means of rudder-like action of the ventral fans, also much more highly developed than in *Stegomyia*, which, furthermore, enable them on occasion to turn sharply so as to attach themselves to any support by means of the hooks of the dorsal brushes, which have just been described.

The function of the hooks was very readily determined by affording larvae in a glass dish, a small twig as a rough object of support. The larvae of all species except *A. asiaticus*, especially those commonly found in moving water—*A. maculatus* and *A. karwari* for instance—invariably take advantage at once of such a support, resting at a right angle to it. Even with the unaided eye, when the larva is at rest against the support, it can be seen that the caudal tufts are so arranged that the ventral group and the inner dorsal brush remain in direct line with the body, the latter just touching the support, and that the dorsal leash of hooked filaments is directed out on either side at an angle of about 45 degrees to the body. If the supporting object is slightly submerged the brushes are directed down, obliquely or vertically, but still occupy the same relative position. By the aid of a microscope it can be determined that the hooklets are twined round any rough point, so neatly sometimes as almost to tempt one to suspect a real tendril-like action.

If the supporting body is dragged through the water, larvae may be drawn along still clinging to it, and the support may be rather violently moved to and fro, the

attached larvae then swaying backwards and forwards from the point of attachment. Larvae are able readily to attach themselves to moving objects.

In this way, then, the larva is able to avoid being swept away, and it can also employ both sets of hooks together at one point, then resting more or less parallel to the supporting object, its head down current, a measure of value doubtless when it has to sustain itself against a greater pressure of water than it could withstand in any other position. When the larva is floating unsupported against any object, the caudal fans are approximated and directed back, and in this position it was noted occasionally, especially in *A. maculatus*, *A. indefinitus* and *A. aitkeni*, that the hooks from the bristles of opposite sides may be interlocked.

Were any confirmation as to the function of the dorsal tufts needed, it is afforded by the study of these structures in *A. aitkeni* and *A. asiaticus*. In *A. aitkeni*, a regular breeder in mountain streams, the number of hooks available for the support of the larva is at least double, since both dorsal tufts bear them. In *A. asiaticus*, a breeder in bamboos, the structures show a very definite tendency to atrophy, a fact suggesting that the very special sort of habitat selected for the larvae is by no means a very recent choice on the part of the female parent, an inference supported by the size of the primitive larval eye, which is very much smaller than in the larvae of any of the other species of the group, and by the absence of the group of pigment spots arranged in crescentic form, which in other species represent the developing compound eye. It is interesting to note in the case of the bush-breeding Anophelines and in *Stegomyia* (also a breeder by preference in dark places), an approximation to a similar condition.* The presence of any hooks at all in the case of *A. subpictus* var. *vagus*, and others which breed by choice in the still water of muddy pools, is doubtless to be explained by recent modification of breeding habits; for until the advent of the white man to this country and the subsequent great economic development, there must have been comparatively few such breeding-places available.

Though these hooks must be the chief means of support to larvae, it is certain that the young larvae of *A. maculatus*, *A. karwari* and *A. aconitus* are able to attach themselves to an object for a short period of time by their mouth-parts. It was necessary in the course of some breeding experiments in connection with these species to transfer young larvae from one porcelain bowl to another, and it was repeatedly found that some with their heads applied to the surface of the bowl could resist withdrawal into a glass tube, and that if a current of water was then directed on them, they were not readily dislodged, swaying to and fro at the point of attachment. The porcelain being glazed, it would appear as if they had some power of attachment thereto by suction, no hooklets being present on the mouth-brushes.

The supporting hooks found in the case of the larva would benefit the several species but little, if there were not some sort of counterpart in the case of the pupa. The usual text-book description of the way in which a pupa evades danger is that it does so by diving and keeping itself submerged. Its specific gravity being less than that of water, it remains below either by getting under some object, or by holding fast by clasping it between its thorax and its flexed abdomen. This appears to be true of certain of the Anophelines, but not of all. It was recognised, for instance, by the writer early in the course of a study of *A. vagus* in its muddy pools that the pupa is able to sustain itself with its tail, apparently just simply applied to any portion of

* In this connection it is noteworthy that, whereas in the fully-grown larvae of *A. hyrcanus* and *A. barbirostris* (open-country breeders) the pigmented elements of both larval and imaginal eyes reach a maximum development, in the case of *A. umbrosus*, the remaining Malayan representative of the *Myzorhynchus* group of Anophelines (a breeder by preference in jungle), they are much reduced in size, especially in the crescentic eye, in which indeed they are so pale that the determination of their presence is difficult.

mud on the bottom. Occasionally a pupa may be seen rising slowly to the surface with material from the bottom dangling from the caudal fins. It has been able so to attach itself by means of a pair of hooklets, one springing from the free margin of each fin, and actually an extension of the thick chitinous bar, which forms a backbone supporting the fin.

If one studies *vagus* pupae in a test-tube, one finds that for the purpose of maintaining themselves below the surface, one of three common methods may be adopted, according to the nature of the supporting material available. First, by preference a pupa will get beneath the supporting object ; secondly, if the object is of convenient size it may clasp it with its anteflexed abdomen ; or thirdly, it may attach itself by the caudal hooks, then rising above the support. Occasionally a pupa of *vagus* has been seen upside down, attached to a rough support by means simply of one respiratory trumpet, showing how slight must be the difference in specific gravity between itself and the water in which it is found. Though the hooks (fig. 3) are present

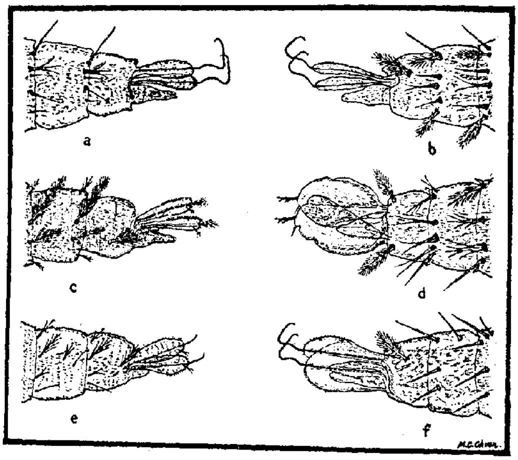


Fig. 3. Terminal segments of pupae of : (*a*) *Anopheles subpictus*, Grassi ; (*b*) *A. subpictus* var. *vagus*, Dön. ; (*c*) *A. asiaticus*, Theo. ; (*d*) *A. hyrcanus*, Pall. ; (*e*) *A. tessellatus*, Theo. ; (*f*) *A. karwari*, James.

in the pupae of *subpictus* (*rossi*), *maculatus*, *karwari*, *aconitus* and *fuliginosus*, they are represented in *sinensis*, *barbirostris*, *umbrosus*, *kochi*, *tessellatus*, *asiaticus*, and, curiously enough, in *aitkeni* also, by a mere filament, and in these latter species, the pupa attaches itself to an object by one of the two ways described first, or, in the absence of any support, remains below by swimming efforts, renewed directly it tends to rise.

The form of the hook varies a little in each species. In all it consists of a stout bristle, which after a short straight course becomes recurved in the direction of the dorsal aspect of the pupa, terminating in a rounded hook. The bristle itself is of brittle material, for often one or both may be broken off short in pupae which have been roughly dealt with.

Conclusions.

1. The larvae of certain Anophelines, particularly *A. maculatus*, *A. karwari* and *A. aitkeni*, occur in streams so swift that their presence would have appeared impossible.

2. Some mechanism must be looked for which would enable larvae to maintain their position in the water.

3. A pair of the dorsal tail brushes, terminated by hooklets, provides this mechanism; and there is a counterpart, in the case of certain pupae, in the form of a pair of hooks terminating the paddles.

The writer's acknowledgments are due to Mr. M. C. Chuen, Laboratory Assistant at the Malaria Bureau, Kuala Lumpur, for the care and skill he has exercised in preparing from living specimens, the drawings which illustrate this note.

Kuala Lumpur, F.M.S.
Sept. 1920.

FLAX CATERPILLARS IN KENYA COLONY, WITH SPECIAL REFERENCE TO THE LIMITATIONS OF THE ROPING METHOD OF COMBATING THEM.

By F. W. Dry, M.Sc.,

Recently Assistant Government Entomologist, Kenya Colony.

Caterpillars on flax in Kenya Colony are farm pests of the first rank. They belong to more than one species, but the one most commonly reared from material from the field is *Phytometra (Plusia) orichalcea*, F.; *Heliothis obsoleta*, F., is also met with.

Caterpillars have been reported from all the chief flax-growing districts of the country: the Kikuyu district, including Kabete, Kyambu, Limuru and Thika, and the districts of Nakuru, Lumbwa and the Uasin Gishu. Near Kericho, which is wetter and colder than Lumbwa, from farms up to within a distance of six miles from those of the Lumbwa area, which have suffered badly, caterpillars have been reported, but no serious damage has been done. Mr. T. J. Anderson, the Government Entomologist, has taken the moths of *Phytometra orichalcea* in the Trans-Nzoia district far from European cultivation.

The caterpillars have a wide range of food-plants. In East Africa they have been found to attack, in addition to flax, Canadian Wonder beans, potatoes, rape and other crucifers, as well as weeds.

The attack on the flax crop may take place at any stage, from the time the crop is only just above the ground up to the time of pulling. In its early stages the crop may be eaten up completely. In the later stages the seed-bolls are especially attacked. In a bad attack on the partly grown crop all the leaves and the tops of the stems are consumed, all that remains being the stripped stalks. When the caterpillars are less numerous a frequent form of damage is that the growing-point at the apex of the plant is killed and several weak secondary stems are thrown out. This results in shortening of the fibre and irregularity in the ripening of the seed.

The damage caused by flax caterpillars has been very serious, and many fields have been destroyed. There have been heavy losses in each of the three years 1918, 1919 and 1920, the worst reports having been received during the last year. Most of the damage is done from May to August, following the long rains, in the main growing season, but outbreaks have also occurred in the season following the short rains, which are due from October to December.

The life-history of *Phytometra orichalcea* was worked out in the laboratory at Kabete during the months of June to August, 1918, comparatively cool months. Eggs were deposited on the leaves or stems of the plants provided. The cocoons were spun on the host-plants, several leaves or stems being bound together. The caterpillars were fed on the weed *Galinosoga parviflora*. Little variation was found in the length of the life-cycle of different individuals. The average times for the different stages were :—

Egg	10 days.
Caterpillar (hatching to spinning cocoon)	41 days.
Cocoon (spinning to emergence of moth)	30 days.

Eggs were laid a day or two after the emergence of the moths, making the length of the life-cycle, from egg to egg, about twelve weeks.

The caterpillar stage lasting, as it does, about six weeks, there is some little time for the detection of the pest while the caterpillars are still small. The large caterpillars are quite conspicuous, but the younger ones harmonise so well with their surroundings that unless a careful search be made they may easily be overlooked.

At least eight species of parasites, some Hymenopterous, some parasitic flies, have been reared from material from the field at Kabete.

Little success in controlling the caterpillars has been obtained by spraying. In May 1919 a number of spraying experiments were carried out in which strong Paris green did produce some results. The Paris green was used at the high rate of 3 lb. to 40 gallons. This was combined with (*a*) soap, (*b*) resin-washing-soda sticker, (*c*) lime, (*d*) lime and sticker. With these four plots were sprayed side by side, and subsequently some small dead caterpillars were found, the caterpillars in the field being mostly only about half-grown. Dead caterpillars could not be found on unsprayed control areas. About ten days after spraying there was a great difference between all these four plots and adjacent control areas. On the Paris green plots little damage could be seen as one looked across the field ; on the controls the caterpillars had retarded the growth considerably. A sharp line was seen between sprayed area and control. Later, the weather being damp, the control areas caught up with the sprayed parts of the field.

At other times spraying experiments with Paris green against larger caterpillars have not met with success. One planter, who did not supply full data, reported success with Paris green and lime, but the position is that one cannot recommend spraying to planters.

The method of combating the caterpillars by "roping" was devised by Mr. J. McDonald, a Lumbwa settler, whose description is now quoted :—

"A rope, 40 yards long and about one inch in diameter, held by a boy at each end, is dragged through the flax, the infested area being gone over from three to six times a day. If necessary more than one rope is kept in action at once. The rope should not be held too tightly. The boys use the same tracks each time and very little mechanical injury will have been done to the crop. The method is continued for several days, until the caterpillars have disappeared."

Here it is interesting to note, though the principle is not the same, that Dutt* in India, speaking of the caterpillars of *Phytometra orichalcea* in peas, says, "Dragging a rope, moistened with kerosine and turpentine, over the crop drives away the caterpillars. Even if they go into the neighbouring fields the crop is saved."

This roping method of Mr. McDonald's has been tried by quite a number of flax-growers. Their reports have varied. Some have said it was entirely successful, others that it was no use. Success, however, was reported in a sufficient number of cases to suggest that the method was of some value, and a week on farms in the Nakuru district, in June 1920, gave the opportunity of applying the tests to this method now described.

The method adopted was to obtain an index of the number of caterpillars in a flax field where roping was in progress and then, four days later, to obtain another index of the numbers present as a test of the result of roping. These numerical estimates were made by walking slowly through the flax and counting the number of caterpillars seen in five minutes, several such counts being made on each occasion. The counts were made by the same people each time, in the same part of the field, and at the same time of the day.

The results may be summarised as follows :—

Field No. 1.—The seed-bolls were just forming on the flax. Caterpillars were quite numerous. Just a very few had formed cocoons. After four days roping with heavy ropes about an inch in diameter the caterpillars were only a quarter as numerous as when the first count was made. There were a few more cocoons than previously,

---

* Report of the Proceedings of the Second Entomological Meeting, held at Pusa on the 5th and 12th February 1917.

but the increase in their numbers was entirely insufficient to account for the reduction in the numbers of caterpillars. Some may possibly have pupated in the ground (but compare with Field No. 2).

Field No. 2.—This field was on the same farm as No. 1 and quite near to it. The flax was nearly ready for pulling. The caterpillars, which were especially attacking the seed-bolls, were rather less numerous than in Field No. 1, but they were rather older and many cocoons had already been spun. The field was treated in the same way as the other, but after four days no reduction was found in the number of caterpillars.

Field No. 3.—In this field on a neighbouring farm the flax was in flower. The caterpillars were about as numerous as in Field No. 1. The field had been gone over about six times a day, but instead of rope, reim (twisted hide) had been used, the reim being much less heavy than the rope used on the first two fields. The reduction in the number of caterpillars was about 35 per cent., as against about 75 per cent. on Field No. 1.

Field No. 4.—As a check on the counts in the above three fields, counts were made on another field, which had not quite reached the flowering stage, where the caterpillars were not very plentiful. They were of fair size, but no cocoons were found. This field was not roped. The number of caterpillars found after the four days' interval was almost identical with that found previously.

Field No. 5.—On this field of flax in flower there was a very bad outbreak. Many of the caterpillars were in the last stage and cocoons were very plentiful. On part of this field the flax had been badly stripped of leaves before the outbreak was observed, and roping started, but caterpillars, while less numerous, were still present in large numbers in other parts of the field, and in these parts not many cocoons were seen. After four days of roping, with ropes about an inch in diameter, dragged through the flax half a dozen times a day, the caterpillars were appreciably fewer than previously on part of the field where the crop had not been seriously damaged, but the roping had not prevented the badly stripped area from increasing in size.

In the last field, some observations were made in order to try to determine just in what way the roping may bring about a reduction in the numbers of the caterpillars. Dead or injured caterpillars on the ground are not objects which readily catch the eye, but when a search was made some injured caterpillars were found. One large caterpillar which could just wriggle a little was found, and an hour later it was unable to move, being apparently dead. Another caterpillar, not very large, was found on the ground, moving only just a little; it did not make any attempt to climb up a flax plant; several small ants, one after the other, were seen to tackle it single-handed, when it would wriggle, and each time they gave up the attempt; but after an hour and a quarter it was attacked by these ants in force and carried off. Other caterpillars, some larger, some smaller, were seen to be attacked by ants successfully. In an area of two square feet where particular search was made, six victims of ants were found. One, which the ants had been watched carrying-off, was found an inch and a half below the surface of the soil. Another, injured at the hind end, succeeded at the third attempt in escaping from its assailants up a flax stem, which it climbed about three inches, but there it hung helpless from a leaf. It was found that a big healthy caterpillar was able to escape, even when placed in an ant-run, but half-grown healthy caterpillars were overwhelmed and carried off by a crowd of ants. Very small caterpillars were several times found being carried by only a single ant.

Obviously, from the fact that great numbers of caterpillars are seen climbing up the plants after being knocked off by the rope, the great majority escape after any one passage of the rope, but if only a small percentage be mortally injured, or placed at the mercy of ants, the cumulative effect would explain how the roping method acts. Six per cent. of casualties each time the rope passes, is sufficient to explain the figures recorded for Field No. 1.

Another explanation of the action of the roping method which has been put forward, is that the caterpillars, becoming weary of being repeatedly knocked off the plants, migrate from the field. A watch was kept for such migration from the field under discussion, but caterpillars were only found crawling out of the field where the flax had been stripped of leaves right up to the edge of the field. Where the flax offered plenty of food, the caterpillars remained there. It seems probable that the roping method, in so far as it does reduce the number of caterpillars, acts not by driving them out of the field, but by bringing about their death in the field.

The conditions involved in the success or failure of this method seem, therefore, to be :—

(1) Kind of rope and frequency of roping.
A heavy rope has more effect than a light one. The more times the field can be gone over in a day the better. If caterpillars are present in sufficient numbers to do appreciable damage, once or twice a day would do little good.

(2) Size of the caterpillars.
On small caterpillars the roping method has an effect both directly, by injury, and indirectly, by placing them at the mercy of ants. On large caterpillars there is little effect by either means.

(3) Numbers of the caterpillars.
Against an outbreak in which the caterpillars were very numerous, I doubt the efficacy of this method, unless, possibly, roping were done more times a day than would be feasible on a farm. Very little success has been reported against bad outbreaks, and in the light of the field observations just recorded this is not surprising. For,

(*a*) It appears that roping produces its effect by bringing about the death of only a small percentage of caterpillars each time the rope passes.

(*b*) Unless the numbers of ants or other predators attacking the caterpillars on the ground are increased by immigration, the larger the numbers of caterpillars, the less potent proportionately will the ants be to reduce the numbers of the caterpillars.

These facts, I believe, explain the different reports on the roping method—some of success, some of failure—which have come to hand. If the caterpillars are big before roping is started, if their numbers are very large, if the rope is too light, or if it is not passed through the field often enough, failure may be expected. But if the caterpillars are small and not present in excessive numbers, roping, properly carried out, will, I believe, meet the case.

It will thus be seen that there are distinct limitations to the roping method, and it is, moreover, a laborious one. Undoubtedly, it will be replaced by something more effective, and at present flax-growers are paying attention to various mechanical devices invented by several settlers for removing the caterpillars from the crop, while the search for other methods is being continued by the Division of Entomology.

THE RED SCALE, CHRYSOMPHALUS AURANTII, MASK., IN KENYA COLONY.

By F. W. Dry, M.Sc.,
Recently Assistant Government Entomologist, Kenya Colony.

The first record of red scale in Kenya Colony in the file of the Entomological Laboratory is for 1914, on citrus. It is known that the scale has been brought into the country in at least one consignment of citrus, which, being accompanied by a certificate from the country of origin that the plants were free from insect pests, was allowed to enter the country under the Plant Import Regulations then in force, without being inspected. It seems, therefore, likely that red scale is not indigenous to the country, but an introduced pest.

In this belief, an attempt at eradication was made, in the hope that the insect might be prevented from becoming established in the country, and the citrus crop thus saved from a costly enemy. This attempt was also undertaken because of the possibility that red scale might attack coffee, a very much more important crop in the country than citrus. This was recognised as a danger for two reasons: first, because red scale in other countries has a very wide range of food-plants; and secondly, because quite a number of scales in Kenya Colony attack both citrus and coffee. These are: *Icerya purchasi*, Mask., *Saissetia hemisphaerica*, Targ., *Saissetia nigra*, Niet., *Coccus hesperidum*, L., *Ceroplastes ceriferus*, And., and *Selenaspidus articulatus*, Morgan.

Accordingly, the importation of citrus into the country was prohibited. At the same time, owners of citrus attacked by red scale were advised to destroy such trees, which were replaced free from the Government Farm, Kabete. Compulsory powers were not sought, but whenever planters were asked to destroy infected trees under this scheme, they consented to do so.

Commencing in 1917, inspections of citrus orchards and nurseries in search of red scale were made by the staff of the Division of Entomology and by the late Mr. J. J. Adams. A circular letter was sent out to citrus owners, accompanied by a specimen of red scale, asking them to make a search for the insect on their trees and to report the result. Sometimes it was found that other insects, such as *Coccus hesperidum* or *Selenaspidus articulatus*, or the citrus Psyllid, *Trioza* sp., were mistaken for red scale, so owners who reported the presence of this insect were asked to send a specimen from their trees.

By these means it was found that red scale was widely distributed in the country and that large numbers of trees were attacked. In some cases, citrus not being a profitable crop, little care has been taken of the trees and the scale has been allowed to multiply unchecked, so that in some neglected orchards great damage has been done by it.

In addition to citrus the plants now known to be hosts of red scale in this country are roses, apple, plum and sisal.

Fortunately, the fears that red scale might attack coffee have not so far been realised, and the following evidence, obtained both in the field and in the laboratory, is encouraging:—

(1) Red scale has never been observed or reported on coffee.

(2) A field of coffee, adjacent to some citrus trees, very badly infested with red scale, has been kept under observation. The citrus is very close to the outside row of coffee, the branches of the two often being in contact. All that has been found on the coffee, are objects that appeared to be red scale larvae, which have secreted the white covering just after settling (this the larvae have also done when put on coffee in the laboratory) and older individuals that were dead and had in all probability been washed off the citrus on to the coffee.

(3) In experiments in the laboratory many hundreds of red scale larvae have been placed on the leaves of coffee plants. Many of them secreted their white covering, but none made any further progress. Larvae similarly placed on citrus as controls lived and attained maturity and themselves produced offspring.

On the citrus plants, to which reference has been just made, the life-history of the red scale was worked out, the larvae having been placed on the plants in the middle of November 1917. The times when the various stages in the life-history were first reached were as follows :—

After the first day most of the larvae had secreted a covering.

After eight days the "pimple" was visible in the centre of the scale.

The first moult took place after 18 days.

The second moult of the female took place after 50 days.

The first male emerged on the 65th day.

The first larvae of the next generation were observed after 110 days.

The average daily temperatures during this life-cycle were: minimum, 54·5° F.; maximum, 80·5° F.

Unfortunately the eradication of red scale has proved impracticable, but we may hope that coffee is immune.

Citrus is not at present an important crop in the country, though a great many people have a small number of trees. At local prices fumigation is impracticable, so that spraying is the control measure recommended.

The West Indian red scale, *Selenaspidus articulatus*, Morgan, has several times been mistaken for the common red scale by citrus owners. It occurs on both citrus and coffee, and has been found in widely separated parts of the country, but has not been known to do serious harm; often only a single individual will be found on one leaf. In one citrus orchard in the Songhor district, a small number of trees could be described as badly infested. The fruit was attacked as well as the leaves, hundreds of individuals being found on a single orange, which was thus rendered quite unsightly.

A citrus plant was infected in the laboratory, at the same time as those on which the red scale life-history was worked out. Larvae of the next generation were first observed after 120 days.

COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st January and 31st March, 1921, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Mr. E. BALLARD, Government Entomologist :—3 Tachinidae, 30 Coleoptera, 100 Thysanoptera, 60 Rhynchota, and a collection of Nematode worms suspected of damaging crops ; from Madras.

Mr. G. E. BODKIN, Government Economic Biologist :—35 Culicidae, 5 Tabanidae, 15 other Diptera, 14 Hymenoptera, 141 Coleoptera, 6 Moths, 50 Isoptera, 2 species of Coccidae, 41 other Rhynchota, 2 Orthoptera, 5 Odonata, 44 Spiders, 4 Scorpions, 2 Centipedes, 5 Millipedes, 2 Worms, and 10 insects attacked by Entomogenous fungi ; from British Guiana.

Mr. HAROLD E. BOX :—8 Tabanidae, 13 other Diptera, and 4 species of Coccidae ; from Argentina.

Mr. P. A. BUXTON :—30 Rhynchota ; from Mesopotamia.

Dr. G. D. H. CARPENTER :—10 Tabanidae, 5 other Diptera, 9 Hymenoptera, 198 Coleoptera, 34 Rhynchota, 26 Orthoptera, and 2 Stone-flies ; from Uganda.

Mr. J. B. CORPORAAL, Entomologist, Algemeen Proefstation, Medan :—8 Curculionidae and 23 Rhynchota ; from Sumatra.

Mr. M. T. DAWE :—1 *Tabanus*, 15 *Glossina*, 60 Coleoptera, 9 Lepidoptera, and 1 species of Coccidae ; from Gambia ; and 8 Tabanidae and 111 Ticks ; from Colombia.

Mr. D. D'EMMEREZ DE CHARMOY :—1 Tube of Cecidomyiidae, 6 Lepidoptera, 1 species of Coccidae, and 300 Aphididae ; from Mauritius.

Dr. EUSTACE W. FERGUSON :—37 Tabanidae ; from Australia.

Mr. T. BAINBRIGGE FLETCHER, Imperial Entomologist :—30 Anoplura ; from India.

Mr. C. C. GOWDEY, Government Entomologist :—220 Ants, 32 Chalcids, 3 other Hymenoptera, 10 Coleoptera, 7 Lepidoptera, 50 Thysanoptera, 7 species of Coccidae, 3 other Rhynchota, 1 Dragon-fly, and 45 Mites ; from Jamaica.

Mr. E. HARGREAVES :—70 Sheep "Ticks," 13 Lepidoptera, and 2 Orthoptera ; from the United Kingdom : and 2 Mutillidae, 115 Coleoptera, and 5 Rhynchota ; from North America.

Mr. H. HARGREAVES, Government Entomologist :—10 Hymenoptera, 123 Coleoptera, and 49 Rhynchota ; from Uganda.

Mr. G. F. HILL, Entomologist, Australian Institute of Tropical Medicine :—191 Culicidae, 59 Tabanidae, 57 other Diptera, 6 Ants, 5 Chalcids, 16 Coleoptera, 12 Isoptera, 5 species of Coccidae, and 4 other Rhynchota ; from Australia.

Dr. WALTHER HORN :—4 specimens of *Chrysops costata*, F. ; from Cuba.

Mr. M. AFZAL HUSAIN, Government Entomologist :—54 Diptera and 33 Chalcids ; from the Punjab.

Mr. J. C. HUTSON, Government Entomologist :—387 Parasitic Hymenoptera, 39 Ticks, and 6 other Arachnida ; from Ceylon.

Mr. F. P. JEPSON, Assistant Government Entomologist :—38 Coleoptera ; from Ceylon.

Mr. L. LEWTON-BRAIN, Director of Agriculture :—5 Diptera, 91 Coleoptera, 24 Lepidoptera, and 14 Orthoptera ; from the Federated Malay States.

Major W. F. M. LOUGHNAN, R.A.M.C. : 4 Tubes of Ceratopogoninae ; from Jamaica and British Honduras.

Mesopotamia, Director of Agriculture :—40 Diptera, 13 Hymenoptera, 37 Coleoptera, 28 Lepidoptera, and 46 Rhynchota ; from Mesopotamia.

Mr. F. Muir :—14 Homoptera ; from Samoa, etc.

Mr. H. K. Munro :—18 Coleoptera ; from South Africa.

Prof. G. H. F. Nuttall, F.R.S. :—2 Tabanidae, 22 *Stomoxys*, 2 Hippoboscidae, and 108 other Diptera ; from Mesopotamia.

The Rev. Father J. A. O'Neil, S.J. :—87 Coleoptera and 7 Moths ; from Southern Rhodesia.

Dr. L. Péringuey, Director of the S. African Museum :—4 Weevils ; from Cape Colony.

Philippine Islands, Director of Agriculture :—8 Orthoptera ; from the Philippines.

Mr. A. W. J. Pomeroy, Government Entomologist :—14 Diptera, 400 Chalcids, 30 other Hymenoptera, and 28 Lepidoptera ; from Nigeria.

Pretoria, Division of Entomology :—84 Orthoptera ; from South Africa.

Mr. A. H. Ritchie :—100 Ants, 3 Chalcids, 152 Coleoptera, 13 species of Coccidae, and 200 Aphididae ; from Jamaica.

Senhor A. F. de Seabra :—18 Orthoptera and 2 Odonata ; from San Thomé.

Dr. B. P. Uvarov :—28 Hymenoptera, 34 Coleoptera, and 4 Rhynchota ; from Transcaucasia.

Mr. Robert Veitch :—29 Diptera, 12 Chalcids, 16 other Hymenoptera, 118 Coleoptera, 50 Lepidoptera, and 30 Rhynchota ; from Fiji.

Sir Francis Watts, K.C.M.G., Imperial Commissioner of Agriculture :—400 Chalcids, 50 Coleoptera, 37 Lepidoptera, 4 species of Coccidae, Aleurodidae and Aphididae, and 2 other Rhynchota ; from the British West Indies.

Wellcome Bureau of Scientific Research :—26 Meloid beetles ; from Peru.

Mr. C. B. Williams :—4 Coleoptera and 13 Rhynchota ; from Trinidad.

A CONTRIBUTION TO KNOWLEDGE OF THE BLOOD-SUCKING DIPTERA OF PALESTINE, OTHER THAN TABANIDAE.*

By MAJOR E. E. AUSTEN, D.S.O.

(Plate IV.)

As in the case of the TABANIDAE, which have already been described,* the material upon which the following paper is based was collected by the author during the Palestine Campaign of 1917–18.

All the specimens, including types of new species, are in the British Museum (Natural History).

Family CHIRONOMIDAE.

Sub-family CERATOPOGONINAE.

Genus **Leptoconops,** Skuse.

Syn. *Tersesthes,* Townsend.

Leptoconops kertészi, Kieffer.†

In abundance near Wadi Ghuzze, on Cairo road about 5 miles S.-W. of Gaza, on afternoon of 14.v.1917; settling in numbers on the faces of the writer and a companion.

L. kertészi, Kieffer, originally described (Ann. Mus. Nat. Hung., vi, pp. 576–577, 1908) from material taken at Cairo, and subsequently recorded by Kieffer (*op. cit.,* xvi, p. 34, 1918) as occurring in Tunisia, is already represented in the National Collection by a series of specimens from Ouargla, Algeria (*Dr. E. Hartert*), March 1912, bearing the following field-note by the collector :—" Exceedingly numerous in some of the oases south of Biskra, and very troublesome to mules." It may be added that at Bir el-Abd, Northern Sinai (50 miles E. of Kantara), 9.xii.1916, the writer met with two females of what appeared to be this species on the margin of a small salt lake, and was bitten by one of them on the arm at midday.

In life the dorsum of the abdomen of this little midge shows a double, longitudinal series of admedian, dark brown blotches, separated by neutral grey‡, triangular interspaces; the venter is whitish; the wings, the surface of which is apparently bare, are uniformly milk-white, except that in each wing the fused ends of the first and third longitudinal veins are expanded to form a kind of *stigma,* which is large and very conspicuous, and of a striking *orange* colour; the halteres are pale buff.

The suggestion by Kieffer (*op. cit.,* vi, p. 577) that *Tersesthes,* Townsend (founded for a species which attacks horses at fairly high altitudes—5,700–7,000 ft.—in New Mexico) is probably identical with *Leptoconops,* Skuse, is undoubtedly correct.

---

* For Tabanidae, *cf.* the author's paper " A Contribution to Knowledge of the Tabanidae of Palestine " : Bull. Ent. Res., x, pt. 3, pp. 277–321, figs. 1–18 (April 1920).

† In 1918 this species was selected by Kieffer as the type of a new genus, which he briefly characterised (Ann. Mus. Nat. Hung., xvi, p. 135, 1918) under the name *Holoconops,* relying upon the number of joints in the antenna of the ♀ to justify a generic distinction. As was recently shown, however, by Mr. H. F. Carter in his admirable " Revision of the Genus Leptoconops, Skuse " (Bull. Ent. Res., xii, pt. 1, pp. 1–28, June 1921), it is impossible to accord to *Holoconops* anything more than subgeneric rank.

‡ For names and illustrations of colours used for descriptive purposes in the present paper, see Ridgway, " Color Standards and Color Nomenclature " (Washington, D.C. Published by the Author, 1912).

(3442) P8/170 1000 8/21 Harrow G 75.

Genus **Culicoides,** Latr.

Synoptic Table.

The eight species described or recorded below are mutually distinguishable as follows:—

1 (4) Wings entirely devoid of markings.
2 (3) Mesonotum and crown of head olivaceous black .. .. *vitreipennis*, sp. n.
3 (2) Mesonotum and crown of head grey (greyish olive) .. *puripennis*, sp. n.
4 (1) Wings with markings.
5 (8) Pale markings on each wing (other than any that there may be at the extreme base) limited to two more or less conspicuous spots or flecks on or close to costal border.
6 (7) Pale wing-markings on costal border clearly defined and conspicuous; mesonotum cinnamon-coloured .. .. *tentorius*, sp. n.
7 (6) Pale wing-markings on or near costal border inconspicuous, and from certain angles visible with difficulty; mesonotum dark mummy-brown *odiatus*, sp. n.
8 (5) Pale markings on each wing (other than those at the extreme base) not limited to two spots or flecks, but much more numerous and extensive.
9 (10) Wings each with three dark blotches on costal border, of which at least the two more distal are (as seen against a light background) conspicuously darker than those elsewhere .. .. *newsteadi*, sp. n.
10 (9) Wings not so marked; darker blotches on costal border (as seen against a light background) not conspicuously deeper in tint than those elsewhere.
11 (12) Mesonotum unicolorous .. .. *guttularis*, Kieffer.
12 (11) Mesonotum not unicolorous.
13 (14) Mesonotum with light grey markings on a dark brown ground; wings with pale spots at their distal extremities directly in contact with the wing-margin, no dark spot in contact with anterior transverse vein *odibilis*, sp. n.
14 (13) Mesonotum speckled; wings in each case with distal pale spot between rami of fourth longitudinal vein not directly in contact with wing-margin, a small but conspicuous dark spot in contact with anterior transverse vein *circumscriptus*, Kieffer.

Culicoides vitreipennis, sp. n.

♀.—Length (one dried specimen), from anterior margin of thorax to posterior extremity of abdomen, 1 mm.; length of wing, 1·25 mm., greatest breadth of wing, 0·6 mm.

Wings hyaline, with a milky appearance but entirely devoid of markings: crown of head and dorsum of thorax olivaceous black; legs pale.

Head: vertex sparsely clothed with short, ochreous hairs, space between upper lobes of eyes with longer ochreous hairs; face and *proboscis* dark brown; inner margins of upper lobes of *eyes* moderately wide apart; *palpi* mummy-brown, third segment oval, moderately swollen; second segment of *antennae* (torus) mummy-brown, relatively large (larger and darker than in the following species), flagellum drab, tinged with brownish towards distal extremity, clothed with yellowish hair, first five or six segments of flagellum more or less spherical in shape, more truncate (more spherical) than in the following species. *Thorax* entirely without markings, mesonotum sparsely clothed with short, ochreous hairs; *scutellum* agreeing in coloration with remainder of dorsum, and bearing one lateral bristle on each side, also (apparently) one central bristle, as well as several short hairs. *Abdomen* (in dried condition) blackish brown, clothed at distal extremity with yellowish hairs. *Wings*

clothed (somewhat less extensively than in following species) with fine, pale, decumbent hairs (macrotrichia), wing-fringe likewise pale; costa as far as end of third vein, first and third longitudinal veins, base of fourth vein as far as anterior transverse vein and anterior transverse vein itself pale cream-buff, otherwise all veins colourless; distal extremity of third longitudinal vein curved round (not bent at an angle) to meet costa, anterior transverse vein if anything slightly shorter than in following species; both radial cells distinct, but not quite so large as in latter. *Halteres* ivory-yellow, stalks brownish at base. *Legs* cream-buff, femora, except at distal extremities, and tibiae, except at their bases, tinged with sepia, extreme tips of femora and extreme bases of tibiae dark brown, extreme tips of hind tibiae mummy-brown on inner side; hair on legs pale yellowish, longer hairs on outer surface of hind tibiae inconspicuous.

Near Jerisheh, 5 miles N.-E. of Jaffa, 1–8.v.1918, in author's tent at night, on lining, above lighted lamp.

The species just described is distinguishable from the European *C. pumilus*, Winn., which it resembles in size and in the coloration of the body, by the much paler wings and legs, and by the decumbent hairs (macrotrichia) on the wings being pale instead of dusky.

Culicoides puripennis, sp. n.

♀.—Length (one dried specimen), from anterior margin of thorax to posterior extremity of abdomen, 1·25 mm.; length of wing, 1·4 mm., greatest breadth of wing, 0·6 mm.

Wings hyaline, somewhat milky, entirely devoid of markings; crown of head and dorsum of thorax deep greyish olive; legs pale.

Head: vertex clothed with pale yellowish hairs, face greyish sepia-coloured; *proboscis* mummy-brown; inner margins of upper lobes of *eyes* closely approximate; *palpi* sepia-coloured, third segment but slightly swollen, first three segments clothed mainly with dark brown or blackish hair, last two segments clothed with ochreous hair; second segment of *antennae* (torus) light sepia-coloured, paler and also somewhat smaller than in foregoing species, flagellum drab, clothed with yellowish hair, five segments following torus bluntly ovoid. *Thorax* entirely without markings, mesonotum clothed with pale yellowish hairs; *scutellum* agreeing in coloration with remainder of dorsum, and apparently bearing two central bristles and on each side two lateral bristles, as well as several short hairs. *Abdomen* (in dried condition) clove-brown, sparsely clothed with pale hairs. *Wings*: greater part of surface, except base and costal, basal and radial cells, clothed with fine, pale, decumbent hairs (macrotrichia), which at and towards distal extremity of each wing are shorter and more closely set; wing-fringe pale; costa as far as end of third vein, first and third longitudinal veins, base of fourth vein as far as anterior transverse vein and anterior transverse vein itself cream-buff (distal half of third longitudinal vein and portion of costa immediately above it somewhat darker), otherwise all veins colourless; distal extremity of third longitudinal vein bent up at an obtuse angle to meet costa, anterior transverse vein fairly long; both radial cells well developed, the first about half as long again as the second. *Halteres*: knobs straw-yellow, stalks slightly darker. *Legs* cream-buff or pale cinnamon-buff, distal extremities of hind femora and hind tibiae sepia-coloured, extreme tips of middle femora and tibiae tinged with brown, first joint of hind tarsi somewhat infuscated; hair on legs pale, inconspicuous.

Deirân (Rechoboth), Jaffa district, 7 miles S.-W. of Ludd, 12.iv.1918, in room at night.

From the foregoing species *C. puripennis* is distinguishable, *inter alia*, by the coloration of the dorsum of the thorax; by the second segment of the antenna being smaller and paler and the following five segments somewhat more elongate; and by the course (angulate instead of rounded) followed by the distal extremity of the third longitudinal vein.

The species just described is also allied to the European *C. albicans*, Winn., from which it may be distinguished owing to the front and middle femora and tibiae not being conspicuously tipped with blackish brown or black, and also (if Winnertz's figure—Linnaea Entomologica, vi, Taf. vi, fig. 35*b* (1852)—is to be relied upon) by the less abruptly turned up distal extremity of the third longitudinal vein.

Culicoides tentorius, sp. n. (Pl. iv, fig. 1).

♂.—Length (3 dried specimens), from anterior margin of thorax to posterior extremity of abdomen, 1·2 to 1·4 mm.; length of wing, 1·5 to 1·75 mm.; greatest breadth of wing, 0·6 mm.

♀.—Length (9 dried specimens), from anterior margin of thorax to posterior extremity of abdomen, 1 to 1·5 mm.; length of wing, 1·4 to 1·6 mm., greatest breadth of wing, 0·75 mm.

Dorsum of thorax (*in dried specimens*) *cinnamon-drab* (♂, *and sometimes* ♀), *or cinnamon-coloured* (♀); *dorsum of abdomen* (*in dried specimens*) *clove-brown or warm sepia-coloured*; *wings mouse-grey* (♂), *or sepia-coloured or dusky-drab* (♀), *an obliquely elongate area at base pale, otherwise in both sexes the only light markings are situate on costal border in shape of a pair of conspicuous ivory-yellow spots, of which that nearer the base is the larger* (Pl. iv, fig. 1); *ground-colour of legs cream-buff or cinnamon-buff, hind tibiae in both sexes fringed posteriorly with a row of long hairs.*

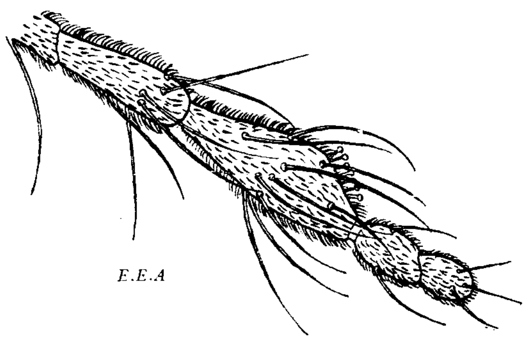


Fig. 1. *Culicoides tentorius*, sp. n.; palpus of ♀.

Head fawn-coloured (face cinnamon-buff), vertex infuscated (blackish-brown or deep mouse-grey) in ♂ and in both sexes clothed with curved, glistening, yellowish hairs; inner margins of upper lobes of *eyes* in ♀ very narrowly separated; *proboscis* and *palpi* cinnamon-buff in ♂, sepia-coloured or dark brown in ♀, palpi in ♀ clothed with brownish hair, third segment moderately swollen towards distal extremity (fig. 1); *antennae* in both sexes cream-buff or light cinnamon-buff (distal segments sometimes darker), fourth to tenth segments in ♀ moderately elongate (fig. 2), hair on antennae, including antennal plume in ♂, glistening yellowish (light ochreous or ochraceous-buff). *Thorax*: dorsum without markings in either sex, sparsely clothed with glistening ochraceous-buff hairs; *scutellum* agreeing in coloration with remainder of dorsum, and bearing in both sexes two central and two lateral bristles, as also several short hairs. *Abdomen* in both sexes clothed with pale yellowish hair. *Hypopygium* of ♂ (fig. 3): ninth sternite deeply notched in middle line; posterior.

margin of ninth tergite also deeply notched, and with relatively broad finger-like extensions; lobe-like processes of lower surface of projecting portion of ninth tergite situate some distance in front of posterior margin; *forceps* of usual form, side-pieces each with two slender, sub-dorsal processes on inner side of proximal extremity; proximal portion of each *harpe* with a strongly chitinised ventral process, at right angles to distal portion, distal portions of harpes noticeably broad, and each tapering

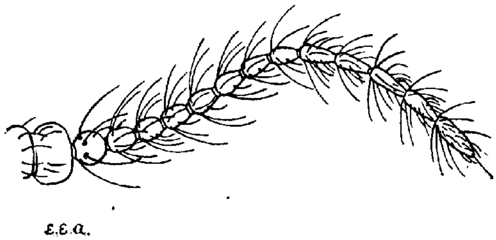


Fig. 2. *Culicoides tentorius*, sp. n.; antenna of ♀.

to a point posteriorly; *aedoeagus* Y-shaped or lyrate, with broad, well chitinised stem, terminating bluntly behind, and with strongly chitinised limbs. *Wings* (Pl. iv, fig. 1) agreeing in both sexes as regards markings; proximal ivory-yellow spot on costa surrounding anterior transverse vein, varying somewhat in size and outline in different individuals, but with its lower extremity reaching fold which traverses fork of fourth longitudinal vein; proximal boundary of distal spot formed

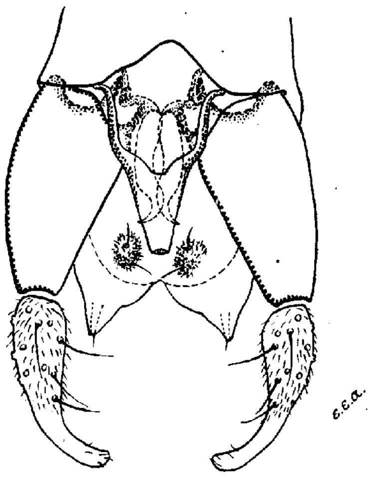


Fig. 3. *Culicoides tentorius*, sp. n.; male hypopygium, ventral view (greatly enlarged).

by or scarcely extending beyond terminal upturned portion of third longitudinal vein; in both sexes portions of costa and of first and third longitudinal veins between spots conspicuously darker than anything else in wing; a larger or smaller area at base of wing pale, portions of veins included in this area, as also anterior transverse vein, upturned terminal portion of third longitudinal vein, and portions of longitudinal veins in proximal costal spot light buff or cream-buff, veins elsewhere, except as already

stated, sepia-coloured; in ♀, decumbent hairs absent from base of wing, including basal cell and costal border as far as end of first longitudinal vein, remainder of wing well clothed with these hairs, which are especially close together on costal border beyond distal costal spot. *Halteres* in both sexes cream-coloured or cream-buff. *Legs*: femora and tibiae, at least of hind legs, usually darker (tinged with mummy-brown or sepia) except at base and tip, so that these joints have a pale band at each extremity, extreme tips of femora and tibiae, at least of hind legs, often mummy-brown.

Near Jerisheh, 5 miles N.-E. of Jaffa, 26.iv.–8.v.1918: type of ♂ and 4 ♂ para-types, type of ♀ and 10 ♀ para-types, in author's tent at night, on lining, above lighted lamp. Not observed biting.

Although in general appearance, including coloration and wing-markings, closely resembling the East and West African *Culicoides* (*Johannseniella*) *fulvithorax*, Austen, the species just described is distinguishable therefrom, *inter alia*, by its generally larger size, by the less elongate shape of the fourth to the tenth segments inclusive of the ♀ antenna, and by the fact that in the wing the distal pale spot on the costa, instead of surrounding the terminal portion of the third longitudinal vein, is only in contact with the upturned part of its extreme tip.

From the N. Italian *Culicoides susae*, Kieff., *C. tentorius* may be distinguished by its larger size, by the fourth to the ninth segments inclusive of the ♀ antenna not being globular, by the halteres being cream-buff or cream-coloured instead of white, and by the presence of a row of long hairs on the extensor surface of the hind tibiae.

Culicoides odiatus, sp. n.

♀.—Length (2 dried specimens), from anterior margin of thorax to posterior extremity of abdomen, 1·4 to 1·5 mm.; length of wing, 1·4 to 1·5 mm., greatest breadth of wing, 0·6 to 0·8 mm.

Dusky species, with very hairy wings, which are almost entirely devoid of markings.—Head and thorax dark mummy-brown (vertex darker), without spots or other markings; abdomen (in dried specimens) russet-brown or russet; wings with markings in each case confined to a pair of small, faint, ill-defined and inconspicuous maculae on or near costal border.

Head clothed above with brownish hair; inner margins of upper lobes of eyes almost in contact below; *proboscis* cinnamon-brown; *palpi* dark mummy-brown, clothed with dark brown hair, third segment strongly swollen, expansion commencing immediately beyond base; *antennae* light sepia-coloured, agreeing closely with those of *C. tentorius*, Austen (*cf.* fig 2, p. 111) as regards shape of segments, and clothed with yellowish (ochraceous-buff) hairs. *Thorax*: mesonotum clothed with ochraceous-buff hairs and with dark brown bristles; *scutellum* bearing, in addition to several short hairs, apparently four central bristles, as also on each side two lateral bristles. *Abdomen* sparsely clothed with pale hairs, except on sides and at distal extremity, where a portion at least of the hairs are dark brownish. *Wings*: with exception of basal and costal cells, practically entire surface clothed with long, closely set, decumbent hairs, which, especially in region beyond level of end of third longitudinal vein, where they are thickest, largely overlap one another; of the two faint pale maculae in each wing, that nearer the base surrounds the anterior transverse vein and extends only indistinctly to the costa, the other is situate on and adjacent to the costa at the end of the third longitudinal vein, the extreme tip of which it includes; second radial cell much broader than the other, which is practically obliterated and indistinguishable. *Halteres* cream-buff, distal extremities of stalks greyish. *Legs*: femora light sepia-coloured (hind pair darker), in each case with a faintly marked pale band (less conspicuous in that of hind pair) before extreme tip.

which is infuscated; tibiae drab-coloured or brownish drab, their extreme tips infuscated; tarsi light ochraceous-buff; tibiae clothed with brownish or yellowish hair, a series of long hairs on extensor surface of hind pair; upper surface of hind tarsi clothed with fairly long, pale hair.

Near Jerisheh, 5 miles N.-E. of Jaffa, 29.iv.–8.v.1918: type and one paratype, in author's tent at night, on lining, above lighted lamp.

The species described above is allied to the foregoing (*C. tentorius*, Austen), but, in the ♀ sex at any rate, is distinguishable *inter alia* by the more swollen third joint of the palpi, by the much darker colour of the dorsum of the thorax, by the wings being much more hairy, and by the two pale spots on the costal border being only faintly indicated and much less developed.

Culicoides newsteadi, sp. n. (Pl. iv, fig. 3).

♀.—Length (3 dried specimens), from anterior margin of thorax to posterior extremity of abdomen, 1·2 mm.; length of wing, 1·3 mm., greatest breadth of wing, 0·6 mm.

Allied to the European C. pulicaris, *L., and agreeing therewith in wing-markings in case of specimens in which pattern shown in* Pl. iv, fig. 3 *is somewhat reduced, but, in ♀ sex at any rate, distinguishable* inter alia *by much smaller size, and by presence of a pale band, sharply defined in case of fully-coloured specimens when viewed against a dark background, at distal extremity as well as at base of hind tibiae.*

Head: vertex sparsely clothed with curved, yellowish hairs; inner margins of upper lobes of *eyes* in contact or separated by an exceedingly narrow interval; *proboscis* dark brown; *palpi* sepia-coloured, clothed partly with brownish, partly with yellowish hair, third segment strongly swollen; *antennae* light sepia-coloured or light mummy-brown, third to tenth segments inclusive generally paler (cream-coloured), hair on antennae yellowish. *Thorax*: dorsum clothed with shining ochraceous-buff hairs, ground-colour (in dried specimens) olive-grey, with a mummy-brown area on each side anteriorly, or light greyish olive, with anteriorly a narrow, sepia-coloured, longitudinal streak in middle line, becoming obsolete towards hind margin, and on each side, between it and lateral border, a broader and longer, curved, longitudinal stripe of same colour; *scutellum* agreeing in ground-colour with remainder of dorsum, and bearing two central and two lateral bristles, as also three short hairs between each central and corresponding lateral bristle. *Abdomen* sparsely clothed with pale (cream- or cream-buff-coloured) hairs. *Wings*: in specimens with fully-developed wing-markings, latter are as shown in Pl. iv, fig. 3, the three dark blotches on costal border dark mouse-grey and very conspicuous, remaining dark markings mouse-grey; in many specimens, however, mouse-grey markings between costal border and hind margin are much reduced in extent, taking form of partly discontinuous and isolated spots and flecks; greater part of distal half of wing-surface, as well as of hind border, fairly thickly clothed with decumbent hairs. *Halteres*: stalks cream-coloured, knobs ivory-yellow. *Legs* sepia-coloured or light sepia-coloured, tarsi, middle and hind knees, and a band at each extremity of hind tibiae paler (pinkish-buff or pale pinkish-buff—in well-coloured specimens pale bands on hind tibiae are cinnamon-buff); hair on legs pale, hind tibiae on outer surface with a row of long hairs.

Near Jerisheh, 5 miles N.-E. of Jaffa, 26.iv.–8.v.1918: type and 5 para-types, in author's tent at night, on lining, above lighted lamp: dedicated, as a trifling token of sincere regard, to Robert Newstead, F.R.S., Dutton Memorial Professor of Entomology, Liverpool School of Tropical Medicine. Although not actually taken *in flagrante delicto*, there can be no doubt that this species is a blood-sucker, since in the case of the type fresh blood was observed in the abdomen at the time of capture.

A ♂ *Culicoides* taken, with specimens of four other species of the same genus, at Sheikh Zowaiid, N. Sinai, 14.iii.1917, in the author's tent at night, and almost certainly belonging to the species just described, measures (in the dried condition) 1·6 mm. in length from the anterior margin of the thorax to the posterior extremity of the abdomen. In the *genitalia*, the side-pieces (basal portions of forceps) are considerably less swollen than in the case of *C. pulicaris*, L., ♂, so that the disparity in size between these and the claspers is not so great. As regards *wing-markings*, with the exception of the distal costal blotch, which is undiminished, all the dark markings are much reduced, those other than on the costal border appearing as some eight or nine faint and almost completely isolated flecks.

Culicoides guttularis, Kieff.

Culicoides guttularis, Kieffer, Ann. Mus. Nat. Hung., xvii, p. 45 (1919).

Three ♀♀, near Jerisheh, 5 miles N.-E. of Jaffa, 29.iv.–8.v.1918, in author's tent at night, on lining, above lighted lamp. Not observed biting, but one of the three specimens brought back has its abdomen distended, apparently with blood.

C. guttularis, the type of which was taken in Hungary (Budapest), also occurs in Great Britain, and has been taken in Middlesex, Herts, Huntingdonshire and the Isle of Arran. The specimens obtained in Palestine differ from the typical form, as described by Kieffer, and agree with British examples, in having a dark transverse mark across the centre of the axillary cell, the distal extremity of which, in contact with the posterior branch of the fifth longitudinal vein, is also infuscated.

Culicoides odibilis, sp. n. (Pl. iv, fig. 2).

♂.—Length (1 dried specimen), from anterior margin of thorax to posterior extremity of abdomen, 1·25 mm.; length of wing, 1·5 mm., greatest breadth of wing, 0·6 mm.

Antennal plume cream-buff (looking brownish in certain aspects, or when the hairs are matted together); dorsum of thorax dark brown, with conspicuous light grey markings; wings infuscated and iridescent, with sharply defined milk-white or cream-coloured spots, as shown in Pl. iv, fig. 2.

Head: *proboscis* and *palpi* mummy-brown, clothed with dusky hairs; torus of *antenna* blackish brown, third to twelfth segments inclusive ivory-yellow or almost colourless, last three segments sepia-coloured in certain lights, clothed with dusky hairs mixed with some pale hairs. *Thorax* dark mummy-brown, mesonotum sparsely clothed with glistening yellowish hairs, and with ground-colour varied by conspicuous and sharply defined light neutral grey markings, chief among which are a sinuous mark, shaped something like a note of interrogation (?), embracing each anterior slit-like depression, a small spot behind each of these marks, a transverse row of four transversely elongate spots across the middle, and a broad, somewhat trident-shaped mark on hind border; base and sides of *scutellum* light neutral grey. *Abdomen* dark neutral grey (claspers paler—light brownish olive), clothed with dusky hair, paler (yellowish) towards the tips. *Hypopygium*: ninth sternite deeply emarginate; posterior margin of ninth tergite not noticeably notched in middle line, finger-like extensions narrower than in *C. guttularis*, Kieff.; lobe-like processes of lower surface of projecting portion of ninth tergite situate some distance in front of posterior margin; *forceps* of usual form, but claspers less elongate than in *C. guttularis*, and their distal extremities not swollen as in the latter species; *harpes* broad, with distal extremity of each attenuate and elongate; limbs of *aedoeagus* strongly chitinised and forming a Y-shaped or lyrate rather than a U-shaped figure, as in *C. guttularis*, stem of aedoeagus moderately broad, apparently rather short, fairly well chitinised and ending bluntly behind. *Wings* (Pl. iv, fig. 2) deep mouse-grey, with a strongly

developed purplish iridescent sheen, and with sharply defined, spot-like, milk-white or cream-coloured markings, chiefly along distal and posterior borders, as shown in figure; hind border of axillary cell to level of axillary angle, and greater part of distal half of each wing fairly thickly clothed with decumbent hairs, which as usual are especially close together on distal third, particularly in area beyond distal costal spot. *Halteres*: knobs straw-yellow, stalks cream-coloured. *Legs*: femora and tibiae light sepia-coloured (hind femora somewhat darker), knees (tips of femora and extreme bases of tibiae) and tips of hind tibiae mummy-brown; tarsi, extreme bases of all femora, a ring immediately before tips of front and middle femora, and a similar ring immediately beyond bases of all tibiae and before tips of hind tibiae cream-coloured; hind femora with a faint indication of a narrow pale ring before tips; hind tibiae with a row of long, dusky hairs on extensor surface, hair on tarsi and on flexor surface of hind tibiae pale.

Near Jerisheh, 5 miles N.-E. of Jaffa, 26.iv.1918; in author's tent at night, on lining, above lighted lamp.

Culicoides odibilis is allied to the foregoing species (*C. guttularis*, Kieff.), from which however it is readily distinguishable by the neutral grey markings on the dorsum of the thorax, by the differences in the ♂ hypopygium detailed above, and by the much more sharply defined wing-markings, in which the pale spots are considerably less extensive.

Culicoides circumscriptus, Kieff.

Culicoides circumscriptus, Kieffer, Ann. Mus. Nat. Hung., xvi, p. 49, fig. 15 (1918).

One ♀, near Jerisheh, 5 miles N.-E. of Jaffa, 29.iv.1918, in author's tent at night, on lining, above lighted lamp.

The specimen referred to agrees on the whole very well with Kieffer's description of the species, the type of which was obtained in Tunis. The inner margins of the upper lobes of the *eyes*, though separated above by a space, the width of which is approximately equal to that of the flagellum of the antenna, are closely approximate below. In the much bespotted *wings*, practically the entire surface of which is thickly clothed with decumbent hairs, the dark fleck (alluded to by Kieffer) enclosed in the proximal pale costal blotch is situate immediately beyond, and in contact with, the anterior transverse vein, occupying the angle formed by the latter and the praefurcal portion of the fourth longitudinal vein; a small pale fleck inside the fork of the fourth vein, close to its base, is not mentioned by Kieffer.

Note.—In an addendum to a short paper by E. Brunetti on "Some Noxious Diptera from Galilee" (Journ. Asiatic Soc. Bengal, New Ser., ix, pp. 43–35, 1913), Dr. N. Annandale writes (*loc. cit.*, p. 45):—"Another irritating blood-sucker common at Tiberias in October, though much less so than *Ph. papatasi*, is a minute Chironomid of the sub-family Ceratopogoninae. Like *Phlebotomus* it is nocturnal in its habits." On p. 370 of Vol. x of the same journal (1914), in a note to Kieffer's description of *Trichotanypus tiberiadis*, Kieff., Dr. Annandale remarks:—"This is the species I referred to in a note on a former paper (J. A. S. B. (n.s.), ix, p. 45, 1913) as being a troublesome bloodsucker at Tiberias." There would appear to be some confusion here, since the genus *Trichotanypus* does not belong to the CERATOPOGONINAE, and the species included in it are structurally incapable of sucking blood.

Genus **Forcipomyia,** (Mg.) Kieffer.*

Forcipomyia (?) **bipunctata,** L. var.

One ♂, Mount of Olives, 1.vii.1918, in Kaiserin Auguste-Viktoria Stiftung, on window.

* No species of this genus is actually known to suck blood.

The only obvious differences from British examples of *F. bipunctata*, L., exhibited by the above specimen are that the hair on the scutellum is paler and perhaps longer, that clothing the distal extremity of the abdomen paler, and that covering the wings apparently shorter, while the knobs of the halteres are dead white without a tinge of yellow.

Family CULICIDAE.

Of the mosquitos collected and bred by the author during 1917–18, a considerable number were subsequently destroyed by Psocids. The material actually brought home includes representatives of 20 species, all but two of which, however, have already been recorded from various localities in Palestine by Captain P. J. Barraud, in a paper published by him in this Bulletin a few months ago.* It will therefore suffice to mention the additions† to Captain Barraud's list, which both belong to the genus *Culex*, and are as follows.

Culex tritaeniorhynchus, Giles.

One ♀, bred, 9.viii.1918, from larva in floating débris: R. Auja, Khirbet Hadrah, 6 miles N.-E. of Jaffa.

Culex modestus, Fic.

Two ♀♀, bred, 14,20.v.1918, from larvae in marsh at Tel Abu Zeitun, near Jerisheh, 5 miles N.-E. of Jaffa.

It may be added that bionomical notes on various species of *Anopheles* will be found in the author's paper entitled " Anti-Mosquito Measures in Palestine during the Campaigns of 1917–1918,"‡ although it now appears that in certain cases the nomenclature there used is in need of revision. Thus—

A maculipennis, Mg., should be *A. maculipennis*, Mg. var.
A. sinensis, Wied., should be *A. hyrcanus*, Pall.
A. palestinensis, Theob., should be *A. superpictus*, Grassi.
A. turkhudi, Liston, should be *A. multicolor*, Camb.

Family SIMULIIDAE.

Genus **Simulium,** Latr.

Simulium flavipes, sp. n.

♂.—Length (4 specimens), 2 mm.

Black; anterior border of dorsum of thorax with a pale neutral grey patch on each side, a similar patch on hind border in front of scutellum; antennae vinaceous cinnamon or light pinkish cinnamon; genitalia indistinguishable from those of S. angustitarsis, *Lundstr.*§; *legs Naples yellow or pale buff yellow, tarsi, tips of tibiae and of hind femora mummy-brown or sepia-coloured, front tarsi slender, not at all expanded, first joint of hind tarsi strongly incrassate.*

Head: *palpi* mummy-brown. *Thorax*: front border of dorsum clothed with minute, appressed, glistening yellowish hairs; meso- and sternopleurae neutral grey or light neutral grey. *Abdomen*: hair on abdominal scale pale yellowish. *Halteres* cream-coloured. *Legs*: front and middle coxae (at least in some specimens)

* " Mosquitos Collected in Palestine and Adjacent Territories," by Captain P. J. Barraud, F.Z.S., F.E.S.: Bull. Ent. Res., xi, pt. 4, pp. 387–395 (March 1921).
† For the identifications of these the author has to thank Mr. F. W. Edwards.
‡ Trans. Soc. Trop. Med. and Hygiene, xiii, no. 4, pp. 47–60 (November 1919).
§ Figured by Edwards, Bull. Ent. Res., vi, pt. 1, p. 24, fig. 1, *i* (June 1915), as those of " *S. aureum.*"

with a dark brown or blackish spot or streak on posterior surface; middle femora with extreme tips light mummy-brown on upper surface; hind legs clothed with fine yellowish hair (tips of tarsi with brownish hair); hind tibiae strongly expanded towards distal extremities; last four joints of front tarsi together approximately equal in length to, or slightly longer than first joint; first joint of hind tarsi somewhat lighter towards base, second joint short but *without any noticeable dorsal excision*, combined length of last four joints of hind tarsi equal to slightly more than half length of first joint.

Wadi el Kelt, Jordan Valley, near Jericho: type and three para-types, 1.vi.1918, forming part of a number of ♂♂ of same species, dancing in small swarms in dry portion of Wadi bed, 5.30–6.30 p.m. At the same time ♀♀ of *Simulium equinum*, L. (see below), were abundant in the ears of horses picketed close by, on top of the Wadi bank.

The species just described is allied to the Algerian *Simulium beckeri*, Roubaud (Bull. Mus. d'Hist. Nat., xii, p. 520, 1906), but is apparently distinguishable, *inter alia*, by its somewhat larger size, and by the leg markings, *e.g.*, by the presence of dark brown or brownish tips to the front and middle tibiae, and by the proximal extremity of the hind tibiae being entirely yellowish (*i.e.*, without a blackish ring at the base). *Simulium flavipes* is also closely allied to an undetermined Ethiopian species (represented in the National Collection by five specimens from Zomba, Nyasaland Protectorate), in which, however, the dark markings of the femora and tibiae are more strongly developed.

Simulium equinum, L.*

Seven ♂♂, Tel Abu Zeitun, near Jerisheh, 5 miles N.-E. of Jaffa, 2.v.1918—part of small swarm dancing at foot of the Tel, near the marsh, 6.15 p.m.; 3 ♀♀, Jericho Plain, 15.iv.1918, "biting horses' ears in morning and evening, all over the Plain" (*Captain Kendle, Australian Veterinary Corps*); 12 ♀♀, Jericho Plain, 19.iv.1918, "in large numbers, attacking insides of horses' ears"; 1 ♀, Hadrah Dam, R. Auja, 29.iv.1918, "flying low over the water, apparently ovipositing on green slime close to the water's edge, 6.15 p.m."; 1 ♀ (pale-legged variety), Jericho Plain, near Wadi el Kelt, 31.v.1918, "in horse's ear in evening."

In the Wadi Hamis, near Ain Kanieh (about 11 miles N.N.-W. of Jerusalem), on 8.iii.1918, at a spot where the shallow water was flowing very swiftly, a greenish *Simulium* larva was present in myriads on the stones in the bed of the stream. No adults were seen, and under the circumstances it was impossible to attempt to breed out any of the larvae. Close to the spot referred to, a number of *Simulium* larvae, apparently belonging to three different species, were also found on the leaves of a submerged piece of reed. Some of these latter larvae were collected and taken back to quarters, and although the majority of those brought back died within two days, two were observed on 10.iii.1918 to have pupated. One of the pupae (examined and sketched as well as possible with the aid of an ordinary platyscopic lens) was found to have on each side six slender respiratory filaments, apparently arising separately from what looked like a long, narrow, whitish pad, the whole arrangement, except as regards the thinness and length of the filaments, being similar to that of the pupal respiratory organs of *S. equinum*, L., as recently figured by Edwards.†

On 19.iv.1918 in the Wadi el Aujah (6½ miles N. of Jericho), a rushing stream of about five yards in width, *Simulium* larvae were abundant on the stones. In fact, just as in the Wadi Hamis six weeks earlier, so numerous were the larvae on some of the stones that the latter looked as though they were hairy.

* For the definite determination of this species, the writer is indebted to Mr. F. W. Edwards.

† F. W. Edwards, Bull. Ent. Res., xi, pt. 3, p. 236, fig. 6 (December 1920).

At Hadrah Dam, R. Auja, on 29.iv.1918, when, as already recorded, a ♀ of *S. equinum* was taken apparently ovipositing, the stones in the bed of one of the sluices were seen to have numerous small *Simulium* larvae on them.

No adults of *Simulium* were observed in Palestine in 1917, but on 9th June in that year larvae were found on stones in running water in the Wadi Shanag (the upper part of the Wadi Ghuzze), at Bir Esani, by Lt.-Col. Richardson, D.S.O., R.A.M.C. Similarly, in the Wadi Ghuzze itself near Tel el Fara, in a rapidly flowing channel issuing from a pool, the writer noticed a few *Simulium* larvae on stones, on 31st July 1917. There can be little doubt that several species of *Simulium*, in addition to the two recorded above, occur in Palestine, and that the genus will be found to exist wherever the presence of running water affords the conditions necessary for breeding.

Family PSYCHODIDAE.

Genus **Phlebotomus,** Rond.

Phlebotomus papatasii, Scop.

Probably abundant during the hotter months in every town and village in Palestine, besides being widely distributed in the open country.

The small amount of material of this species which the author succeeded in bringing home in safety consists of :—2 ♂♂, 4 ♀♀, Deir el Belah, 8 miles S.-W. of Gaza, 13.viii.1917, in corners of an " E.P." tent, 10.30 a.m. ; 1 ♀ (abdomen distended by eggs), Deir el Belah, 22.viii.1917, in circular tent (alongside earth bank surmounted by cactus hedge) in which a case of " sand-fly (*Phlebotomus*) fever " had occurred; 1 ♀, Deir el Belah, 8.ix.1917—both sexes numerous in upper corners of E.P. tent, used as office by 14th Coy. (A.T.) R.E., in palm grove at No. 14 Well ; 2 ♂♂, 2 ♀♀, Bir ez Zeit (13 miles N. of Jerusalem), 22.vii.1918, in house—at least 5 ♀♀ seen in dark, cellar-like basement of one house, and a number more specimens of both sexes (one ♀ full of partly digested blood) in a dark, open cupboard in a room on first floor of another dwelling ; 1 ♀, Et Tireh (about 5 miles N.N.-E. of Ludd), in corner of dark granary ; 1 ♀, Mulebbis, 2.viii.1918—with another specimen, in corner of packing shed at orange grove.

More than one of the females enumerated above, which has the wing fringes, especially those on the costal margins, decidedly dark, apparently belongs to Newstead's " *Dark form.*"*

In July and August 1917, the occurrence of a number of cases of sand-fly fever in the E.E.F. at Deir el-Belah caused attention to be directed to *Ph. papatasii*, which was at that time common in many places in dug-outs and tents, in the case of the latter, especially such as were pitched in the palm groves near the wells or close to banks of earth crowned with cactus hedges. Efforts to find breeding places failed, though possibly lizard holes, more particularly the burrows of *Agama stellio*, L. (" *Hardun* " of the Arabs), the large repulsive-looking lizard so common about cactus hedges in Palestine, may be among the sheltered retreats serving the insects as nurseries. At Deir el Belah, 13.viii.1917, at 10.30 a.m., the writer found *Ph. papatasii* abundant in an E.P. tent, situated in a garden close to a well and occupied as sleeping quarters by enginemen working the pump at the latter. The insects were in numbers in the upper corners of the tent, sheltering behind the valances and at the back of framed photographs hung across the corners ; there were also several inside helmets and coats hanging on the tent-pole. Both sexes were present, ♀♀, the majority of which were gorged with blood, perhaps slightly predominating ; over 20 specimens were caught in tubes with little difficulty. At

* Newstead, Bull. Ent. Res., ii, p. 73 (1911).

Jericho, in May–June 1918, *Ph. papatasii* was fairly common, and in the compound of the Pilgrim's Hospice at 4.45 a.m. on 7.vi.1918, the author was bitten on the back of the hand by a ♀ of this species, in broad daylight. On 2.x.1918, when occupying a tent on a spur of Mt. Carmel, above Haifa, the writer observed a ♂ *Ph. papatasii* inside his mosquito net.

Phlebotomus minutus, Rond., var. **africanus,** Newst.

The following are the data with regard to the few specimens of this insect brought back by the author :—1 ♂, near Jerisheh, 5 miles N.-E. of Jaffa, 7.v.1918, in author's tent, 8.0 a.m. ; 1 ♀, same locality and place, 15.v.1918, 7.15 p.m. ; 2 ♂♂, 2 ♀♀, near Yahudiyeh, about 8 miles E. of Jaffa, 24.viii.1918, in E.P. tent in olive grove ; 1 ♂, 6 ♀♀, and 3 ♂♂, 7 ♀♀, near Jerisheh, 26.viii. and 3.ix.1918, behind hanging valance of E.P. tent, in open country.

In the Jaffa district, at any rate during the period July–September 1918, *Ph. minutus* var. *africanus* was generally to be found sheltering in numbers behind the hanging flaps or valances in E.P. tents, while, if the settlement of Wilhelma may be taken as a criterion, it was also common in villages. On 30.vii.1918, the writer was informed by Captain (afterwards Major) W. F. Corfield, D.A.D.M.S., 54th Division, that the fly was abundant in all the houses in Wilhelma, and that in the room used as the informant's mess, 40 or 50 specimens were sometimes seen, or were caught on the lamp, in one evening. On making a search in the office of the A.D.M.S., 54th Division, in Wilhelma, the writer found two examples of what appeared to be *Ph. minutus* var. *africanus*, while in the cellar-like basement of the same house several more specimens of this *Phlebotomus*, including a female gorged with blood, were seen and caught. Since every house in Wilhelma is provided with a basement, the walls of which, being built of rough stone, are full of cracks and crannies forming ideal breeding and sheltering places, the local abundance of these "sand-flies" was scarcely surprising, while, at any rate under active service conditions, effective prophylactic measures were of course impossible.

When collecting specimens of *Ph. minutus* var. *africanus* in their favourite retreats in E.P. tents, it was noticed that on first being uncovered they are often, or usually, so completely motionless that they appear to be dead. On being disturbed, however, they become very active, either jumping from side to side after the manner of *Ph. papatasii*, or just as frequently taking wing at once. Placed in tubes loosely plugged with cotton wool, these little flies frequently burrow into the wool like minute mice, and then remain perfectly motionless. In the Jerisheh-Wilhelma region, in the summer of 1918, occasional specimens of *Ph. papatasii* were seen or caught in company with *Ph. minutus* var. *africanus*, though the latter appeared to be far more numerous. Like *Ph. papatasii*, *Ph. minutus* var. *africanus* sometimes shelters among clothing hanging on tent-poles ; thus, near Jerisheh on 7.ix.1918, the author took 1 ♂ and 3 ♀♀ of this variety among the folds of a Burberry suspended from the pole in his tent. None of these females had blood in them, and no specimens of *Ph. minutus* var. *africanus* were ever observed to bite ; in fact the finding in the basement of a house at Wilhelma, as mentioned above, of a single female gorged with blood was the only evidence obtained that the present variety is actually a blood-sucking fly. It only remains to add that whenever a series of specimens was collected, females were found to be much more numerous than males, and that a single male taken by the writer, 26.ix.1918, in his tent at Tul Keram, appeared to belong to the variety under discussion.

Writing from observations made during a five weeks' visit to southern Galilee and Syria in October and November 1912, Dr. N. Annandale says* :—"By far the

* Journ. Asiatic Soc. Bengal, ix, pp. 44–45 (1913).

most troublesome blood-sucking flies at Tiberias and Nazareth in October are the so-called sand-flies of the genus *Phlebotomus* (fam. Psychodidae). They occur in large numbers in every house, concealing themselves during the day in ceilings or dark corners to which they retire shortly after sunrise, and commencing their onslaught, which is continued until they retire, at sunset. Although I was unable to find the larvae, I obtained indirect evidence that they breed in half-dried algae just above the water level on the sides of open cisterns. Miss S. L. M. Summers, of the London School of Tropical Medicine, who has been kind enough to examine the adult specimens I collected, finds only two species (*Ph. papatasi* [*sic*], Scop., and *Ph. minutus*, Rond.), among them, thus confirming the preliminary diagnosis made in the field. Col. Alcock tells me that he found the same two species, and them only, in a large collection from Aleppo. *Phlebotomus* apparently occurs at Tiberias practically throughout the year, but at Damascus, in which it is troublesome in summer, it had entirely disappeared before the end of October. I did not obtain *Ph. minutus* at Nazareth, and at Tiberias it was much less common than *Ph. papatasi*."

Genus et sp. incert.

At Bir Esani, 24.x.1917, in the Wadi Immalaga near its mouth, on a ladleful of water just taken from among bulrushes, the author found a small Psychodid with a distinct proboscis and slightly spotted wings. Most unfortunately the specimen, which was quite unlike anything seen before or since, was blown away before it could be secured.

Family MUSCIDAE.

Genus **Philaematomyia,** Austen.

Philaematomyia crassirostris, Stein.

Musca crassirostris, Stein, Mitt. Zool. Mus. Berlin, ii, p. 99 (1903)

Philaematomyia insignis, Austen, Ann. & Mag. Nat. Hist. (8) iii, p. 298, figs. i–iii (1909).

Eleven ♂♂, 11 ♀♀, Latron, close to Jaffa-Jerusalem road, 5.ix.1918; 1 ♀, Tul Keram, 26.ix.1918 (*Lt.-Col. (temp. Col.) E. P. Sewell, C.M.G., D.S.O., R.A.M.C.*).

Although from the moment of entering Palestine the writer kept a sharp look-out for this widely-distributed species, it was not met with at all during 1917, and even in 1918 it was not observed until 5th September, when the author took it in abundance on his own person, at Latron. Had cattle been examined, the fly would very possibly have been encountered earlier.* Patton and Cragg,† writing of *Philaematomyia insignis*, Austen (=*Ph.* (*Musca*) *crassirostris*, Stein), as observed by them in Madras, state that flies of this species "feed almost exclusively upon cattle and . . . . . . only occasionally bite human beings." The present writer's experience tends to support this statement. At Latron on the date mentioned he took both sexes of *Philaematomyia crassirostris* in numbers on his puttees (24 specimens—11 ♂♂, 13 ♀♀—were caught without difficulty in a killing tube), all the insects being actively engaged in probing the material with their proboscises, evidently in search of nutriment; while, although the writer's arms were bare and perspiring, only a few specimens settled upon them, and only one of these latter flies (a ♀)

* In Galilee, in October 1912, according to Dr. N. Annandale, the present species was "by far the commonest blood-sucking fly on horses and cattle":—*cf.* E. Brunetti, "Some Noxious Diptera from Galilee" (Journ. Proc. Asiatic Soc. Bengal, ix, p. 43, 1913).

† Annals of Tropical Medicine and Parasitology, v, p. 518 (1912).

attempted to bite. It was felt at the time that so unmistakable a predilection for settling upon and feeding from a hairy surface could scarcely be without significance. The ♀ taken in the act of biting the author's arm caused a sharp, pricking sensation, which lasted for several minutes, although there was no visible blood at the bitten spot. The ♀ caught at Tul Keram by Colonel Sewell bit its captor on his bare leg at 7.30 a.m., while he was dressing in his tent; though disturbed before it had time to draw blood, the fly left a mark upon the skin.

The *greyness* of the ♀♀ of this species in life is very noticeable; male specimens do not appear nearly so grey. Another remarkable characteristic of this fly is the *softness* of its body; when pinning the specimens taken at Latron, which did not appear to be newly-emerged, the author found it difficult to impale them on No. 20 pins, without crushing in the dorsum of the thorax, and the contrast in this respect between *Ph. crassirostris* and *Musca domestica* or *M. autumnalis* was most striking.

Genus **Stomoxys**, Geoff.

Stomoxys calcitrans, Linn.

One ♂, 2 ♀♀, Deir el-Belah, 8 miles S.-W. of Gaza, 7,20.iv.1917; 1 ♀, Jaffa, 26.ii.1918, in house; 1 ♀, Wadi Hanein, near Richon le Sion, 9.iv.1918; 1 ♂, 1 ♀, Deiran, 11.iv.1918, *in coitû*.

Generally distributed. Brunetti (*loc. cit.*) states that in October 1912 this species was met with in houses at Nazareth and Tiberias by Dr. N. Annandale, who writes (*ibid.*) that it was "also seen commonly on cattle."

Genus **Lyperosia**, Rond.

Lyperosia irritans, Linn.

Fairly common in Wadi Ghuzze, near El Shellal, 11.xi.1917, when a number of specimens settled on author's sleeve, but did not attempt to bite; 1 ♂, 3 ♀♀, Ain es-Sultan, near Jericho, 22.iv.1918, on horses.

[**Lyperosia minuta,** Bezzi.—Brunetti (Journ. Proc. Asiatic Soc. Bengal, ix, p. 43, 1913) records a single ♀ of this species as having been taken at Tiberias, in October 1912, by Dr. N. Annandale, who writes (*loc. cit.*):—"The specimen was caught biting my hand at night. What I take to be this species is very troublesome, especially in the early morning and at sunset, on the shores of the Lake of Tiberias, easily piercing ordinary flannel with its proboscis. The wound is not very painful and does not as a rule become inflamed."]

Family HIPPOBOSCIDAE.

Genus **Hippobosca**, Linn.

Hippobosca equina, Linn.

One ♀, near Jericho, 6.iii.1918 (*Captain* (*acting Lt.-Col.*) *W. J. Dale, O.B.E., R.A.V.C.*); 1 ♀, Deir el-Belah, 8 miles S.-W. of Gaza, v.1917; 1 ♀, near Jerisheh, 5 miles N.-E. of Jaffa, between 1.v. and 8.v.1918; 1 ♂, 1 ♀, Mulebbis, 21.v.1918, on cow (*Captain C. Searle, M.C., R.A.M.C.*); 1 ♂, Jericho Plain, 26.v.1918, on horse; 3 ♀♀, Mount of Olives, 26.v.1918, on horse (*Captain* (*acting Lt.-Col.*) *Dale*); 1 ♂, 1 ♀, Mount of Olives, 20.vi.1918, inside Kaiserin Auguste-Viktoria Stiftung; 1 ♂, Tul Keram, 27.ix.1918.

Brunetti (*loc. cit.*, p. 44) mentions that in October 1912 specimens of this species were taken by Dr. N. Annandale at Tiberias, Nazareth, and Kefr Kenna, "sucking blood of horses." The collector states (*loc. cit.*) that in Galilee *H. equina* is "very common on horses and cattle."

Hippobosca capensis, v. Olf.

One ♂, 1 ♀, Deir el-Belah, 8 miles S.-W. of Gaza, v.1917; 1 ♂, near Kefr Insha, about 20 miles E. of Jaffa, 21.v.1918, settled in ear of author while he was travelling in motor car; 1 ♂, Mount of Olives, 6.vii.1918, inside Kaiserin Auguste-Viktoria Stiftung, on author's neck; one specimen (sex uncertain, abdomen missing), near Abud, 19 miles E. of Jaffa, 25.viii.1918, on author's arm.

Hippobosca camelina, Leach.

One ♂, near Jericho, 6.iii.1918 (*Captain (acting Lt.-Col.) W. J. Dale, O.B.E., R.A.V.C.*); 1 ♀, Tel es-Sultan, near Jericho, 21.iii.1918, caught in horse lines, with many specimens of *Hippobosca equina*, Linn. (*Captain W. W. Averill, Auckland Mtd. Rifles*); 1 ♂, 4 ♀♀, Deir el-Belah, 8 miles S.-W. of Gaza, 2.ix.1917, on camels.

It may be mentioned that a somewhat misshapen pupa (puparium), deposited prematurely by one of the specimens last referred to, measures 7 mm. in length, while the dimensions of a fully mature, empty puparium of *H. camelina*, obtained at Biskra, Algeria, 3.iii.1894 (*Rev. A. E. Eaton*) are—length, 6 mm., greatest breadth, 5·4 mm.

Owing to the very large number of camels (some 30,000), chiefly from Egypt, serving with the Egyptian Expeditionary Force in 1917–18, this species could have been taken practically anywhere within the British lines in Palestine, at any rate wherever there was a detachment of the Imperial Camel Corps or section of the Camel Transport Corps.

Genus **Lynchia,** Weyenb.

Lynchia maura, Big.

Three ♂♂, 3 ♀♀, Deir el-Belah, 8 miles S.-W. of Gaza, 23.viii.1917, on carrier-pigeons belonging to Army Signal Service, R.E.

In the warmer parts of the earth, including southern Europe, this well-known parasite of the domestic pigeon and disseminator of the haematozoon, *Haemoproteus columbae*, Celli & Sanf., is nowadays to be found on its host practically wherever the latter occurs. The *Lynchia maura* series already in the British Museum (Natural History) includes specimens from the Canary Islands (Orotava, Teneriffe); N. Nigeria (Hadeija); Nyasaland Protectorate (Kanyenda, Dwangwa R., W. Nyasa); Union of South Africa (Cape Town, and Mowbray, Cape Province; Pretoria and Onderstepoort, Transvaal); Mauritius; Mesopotamia (Qurnah, R. Tigris); India (Deesa, Ambala, Bangalore); Selangor (Kwala Lumpur); Jamaica (Spanish Town); and Brazil (Pará). Knab (Insec. Inscit. Mens., iv, 1916, p. 3), who gives records ranging from Iowa to Southern Brazil (S. Paulo), states that the species "is widely distributed in America," and that recently it "has made its appearance in the Hawaiian Islands."

Apart from the dissemination of haematozoa, pathogenic or otherwise, by *Lynchia maura*, these flies, several of which may occur on the same bird, are prejudicial to carrier-pigeons by disturbing their rest. It was found in Palestine that an infested pigeon on returning from a flight, instead of at once seeking its resting place, as these birds usually do, would alight on the floor of the loft and proceed to stamp and peck itself.

Genus **Lipoptena,** Nitzsch.

Lipoptena caprina, sp. n.

♂♀.—Length, ♂ (7 specimens), 3·2 to 3·8 mm. (from anterior margin of clypeus to posterior margin of scutellum, 2 to 2·2 mm.), ♀ (3 specimens), 3·8 to 5 mm. (from anterior margin of clypeus to posterior margin of scutellum, 2·4 mm.); width of head, ♂, 1 to just over 1 mm., ♀, 1·25 mm.

Dorsum of thorax (in dried specimens) *shining mummy-brown; chitin plates on dorsum of abdomen small (first three plates in ♀ minute); entire dorsum of abdomen of ♂ from posterior margin of basal segment backwards inclusive, except greater part of the four plates of chitin and area immediately in front of last plate, thickly clothed with relatively long, recumbent, cinnamon-rufous hair; corresponding area of dorsum of abdomen of ♀ clothed for most part with very short hair.*

Head: dorsal surface, including *antennae*, ochraceous-tawny, *vertical triangle* (ocelligerous plate) dark brown or dark mummy-brown, nearly semi-circular and extending much further forward than in *L. cervi*, L., *frontal stripe* cinnamon-brown, sepia-coloured or light mummy-brown, about half as broad again as long; each *inner orbit* at its widest equal to or slightly exceeding extreme breadth of corresponding eye; *clypeus* generally with a more or less distinct, isolated, pit-like depression in middle line, midway between pit at posterior end of median longitudinal groove and its hind margin, a dark brown horseshoe-shaped mark (more or less complete or widely interrupted in middle line), usually fairly well defined, and with forwardly directed concavity, encircling pit at end of median longitudinal groove, each arm of the horseshoe running along inner edge of corresponding antennary pit, but not reaching front margin of clypeus, a second, narrower, dark brown, curved mark, interrupted in middle line by posterior pit-like depression, behind horseshoe and midway between it and posterior margin of clypeus, arms of posterior curved mark not extending so far forward as those of horseshoe, area adjacent to pit at posterior end of median longitudinal groove brownish; *palpi* dark brown, short; hair on ventral surface of anterior border of head brownish at base, glistening ochraceous-tawny towards distal extremity. *Cephalic chaetotaxy*: one bristle close to inner upper angle of each orbit, on a level with posterior ocelli; two bristles side by side on each inner orbit, in a row extending obliquely forwards and inwards on a level with upper margin of eye; one bristle (occasionally two bristles) on inner margin of each orbit close to upper boundary of clypeus. *Thorax*: dorsum clothed with hair and bristles of moderate length, dark brown at base, glistening cinnamon-rufous towards their distal extremities; middle line of mesonotum bordered on each side with a curved row of bristles, commencing anteriorly a little in advance of hind margin of humeral callus; humeral calli each with six or seven bristles, postalar calli each with three bristles; lateral area of mesonotum on each side clothed fairly thickly with bristles, of which those forming a transverse row on upper surface of protuberance in front of base of each wing-stump are stouter and recurved; *scutellum* sometimes showing a pit-like depression (perhaps due to *post mortem* shrinkage) near each lateral angle, sometimes also with a similar depression in middle line; hind margin of scutellum with six bristles. Each half of mesosternum roughly quadrate in outline when seen from below, considerably larger than corresponding half of metasternum, and closely beset with very short dark brown bristles, those on hind margin, apart from usual long, hair-like bristle in front of socket of middle leg, larger and stouter than elsewhere; short bristles on metasternum smaller and fewer than those on mesosternum, though in this case also bristles on hind margin are stouter than remainder. *Abdomen*: dorsum of ♂ with basal segment of usual type, followed in middle line by four small, transversely elongate plates of shining dark brown chitin, widely separated by pinkish buff or cinnamon-buff integument; transverse diameter of last two plates about the same (0·6 mm.), but last plate considerably deeper (*i.e.*, longer when measured from front to rear) than penultimate, the two anterior plates very small, one-third or considerably less than half the size of the penultimate, basal segment, except hind margin, clothed with short, appressed, dark brown hair; venter cinnamon-buff, with a large horseshoe-shaped, dark neutral grey mark not extending to distal extremity, and entire surface thickly clothed with short hair, similar in colour and character to that on dorsum; dorsum of abdomen of ♀ with basal segment similar to that of ♂, followed in middle line by four plates of chitin widely separated by light ochraceous-buff integument, the terminal plate,

consisting of dark brown chitin, situate at bottom of notch or depression in hind margin of abdomen, and about equal in size to corresponding plate in ♂, remaining plates very small, light mummy-brown in colour and transversely elliptical or elliptical oval in shape, the penultimate plate and the plate immediately following the basal segment between one-third and one-fourth of the terminal plate in size, the antepenultimate plate considerably smaller than either of the two plates between which it is situate; dorsum in ♀ sparsely clothed with appressed, dark brown, chestnut-brown or cinnamon-rufous hair, very short except on hind margin of basal segment and on lateral margins of posterior half of abdomen, and, with exceptions stated, much shorter than corresponding hair in ♂, each of the four median chitinous plates with a more or less complete row of short hairs, varying in number, on or close to its hind margin; venter cinnamon-buff, fairly densely clothed with minute, appressed, dark brown, chestnut-brown, or cinnamon-rufous hair. *Legs*, except tarsi, buff-yellow or ochraceous-buff, front and middle femora brownish above towards distal extremities, anterior surfaces of front and middle tibiae also more or less brownish; tarsi cinnamon-brown or chestnut-brown; bristles and hairs on legs dark brown to cinnamon-rufous, stouter bristles dark brown at base, then paler.

Jerusalem and Ain Arik (10 miles N.N.-W. of Jerusalem): type of ♂, and 5 ♂ and 2 ♀ para-types, taken at Jerusalem, 29.vi.1918, on goats and kids; type of ♀, and 1 ♂ para-type, caught at Ain Arik, 15.vii.1918, on a kid. In all cases the insects were on the inside of the thighs; at Jerusalem on 29.vi.1918 several specimens were found on one small kid. It may be noted that, in addition to harbouring the parasite just described, the goats examined, which appeared to be perfectly healthy, were also infested with ticks, specimens of which, apparently belonging to two or three species, were numerous on the inside of the animals' ears.

Among the microscopic preparations forming part of the National Collection of Diptera is a ♀ *Lipoptena*, which is evidently conspecific with the specimens enumerated above, and was taken on man at Snevce, Macedonia, in May 1918 (*Col. C. M. Wenyon, C.M.G., C.B.E., late A.M.S.*).

In general appearance *Lipoptena caprina* presents a close resemblance to *L. ibicis*, Theob. (Second Report Wellcome Research Labs., Khartoum, 1906, p. 88, figs. 45–47), which was described from specimens found on an ibex at Port Sudan, Anglo-Egyptian Sudan. The new species agrees with *L. ibicis* with respect to size, etc., of the abdominal plates of chitin and as regards the hairiness of the body, but is distinguishable by the row of bristles running obliquely across each inner orbit consisting of only two instead of three or four, or sometimes even five bristles, and by the antero-posterior diameter of the vertical triangle (ocelligerous plate) being if anything slightly longer.

Owing to similarity of provenance, it might be reasonable to assume the identity of *Lipoptena ibicis*, Theob., with *L. chalcomelaena*, Speiser (Zeitschr. f. syst. Hym. u. Dipt., iv, p. 178, 1906), the typical series of which was obtained at Tor (Peninsula of Sinai) on "*Capra caucasica*" (*Capra aegagrus*, Gmel. ?). While, however, the number of bristles in the row running obliquely across the inner orbits as given by Speiser for *L. chalcomelaena* agrees with what is found in *L. ibicis*, Speiser in describing the abdomen of the male of his species gives no indication of special hairiness; on the other hand he describes the vertical triangle on the head as "broad and short," whereas in *L. ibicis*, Theob., the antero-posterior diameter of the corresponding plate is considerably longer than in *L. cervi*, Linn. On the other hand, in a subsequent paper (*op. cit.*, v, p. 354, 1905), Speiser, when giving additional localities for his species, mentions that the majority of the specimens afterwards examined by him were collected in Egypt (two on the shores of the Red Sea), and that all of these bore a label with the MS. name of "*L. hirta*, Löw." This would suggest that if Speiser has correctly identified these latter specimens as belonging to his own species, *Lipoptena ibicis*, Theob., may still be a synonym of *L. chalcomelaena*, Speiser.

EXPLANATION OF PLATE IV.

Fig. 1.—Wing of *Culicoides tentorius*, Austen, ♀. × **75**.

Fig. 2.—Wing of *Culicoides odibilis*, Austen, ♂. × **75**.

Fig. 3.—Wing of *Culicoides newsteadi*, Austen, ♀. × **75**.

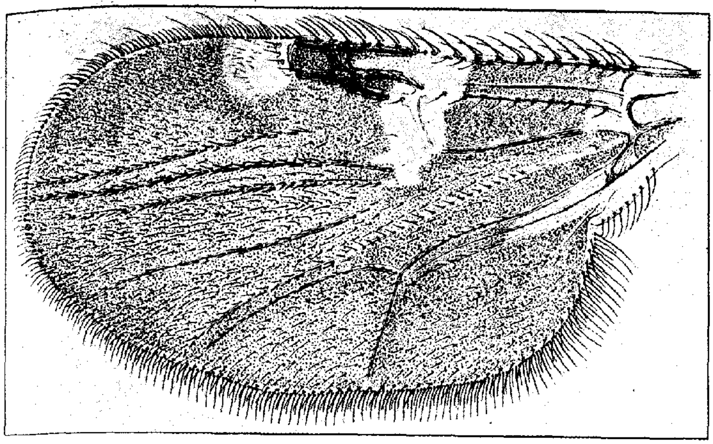


Fig. 1. *Culicoides tentorius*, sp. n., ♀ (× 75).

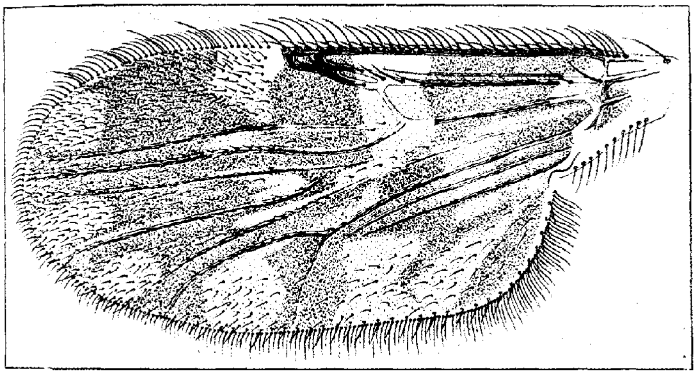
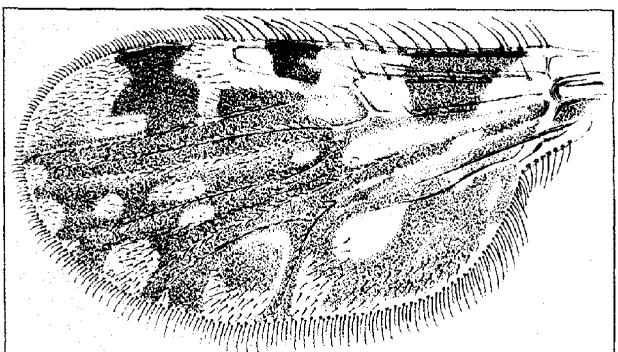


Fig. 2. *Culicoides odibilis*, sp. n., ♂ (× 75).



E. E. Austen ad nat. del.

Fig. 3 *Culicoides newsteadi*, sp. n., ♀ (× 75).

COCCIDAE FROM THE SEYCHELLES.

By E. E. Green and F. Laing.

Pseudaonidia iota, sp. n.

Adult female pyriform, broadest across the meso- and metathorax; cephalothoracic area rounded in front, slightly contracted behind, where there is a well-defined transverse grove; abdomen tapering to the posterior extremity; frons and margins of thorax and abdomen with a few spiniform setae. Antennae rudimentary, each bearing a single long straight seta. Anterior spiracles with a small group of parastigmatic pores (fig. 1, A). Pygidium with a well defined, strongly chitinised, pyriform, reticulated area, the lacunae oval or round, and disposed regularly; the part posterior to the anus, very heavily chitinised, obscuring the lacunae. Circumgenital glands present, consisting of a continuous arch representing the united median and

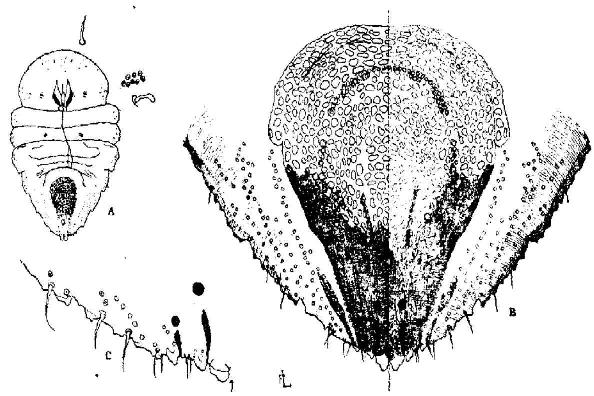


Fig. 1. *Pseudaonidia iota*, sp. n.: A, adult, × 30; B, pygidium, × 150; C, margin of pygidium, × 250.

anterior lateral groups, with the posterior laterals separated by a short space; the anterior laterals show signs of being in two rows. Dorsal pores numerous, comparatively small, circular, arranged in longitudinal series on each side of the pygidium, and extending on to the margins of the abdomen (fig. 1, B). Pygidial margin with three pairs of lobes and numerous angular projections laterad, each lobe notched on the outer side; two pairs of conspicuous claviform paraphyses, each with a large separate circular knob like the dot of an *i* (fig. 1, C). Length, 1 mm.; greatest breadth about 0·75 mm.

Described from a single example.

On upper surface of leaf of *Eugenia caryophyllata*, Seychelles (*P. R. Dupont*).

The paraphyses of this species resemble those to be found in *P. lacinia*, Brain (Bull. Ent. Res., ix, 3, p. 207, March 1919), but the two species may be readily separated by the absence of circumgenital glands in the latter.

Pseudaonidia aldabraca, sp. n.

Puparium of female more or less circular, brownish, partly overlaid with greyish-white secretion. Diameter approximately 2 mm.; exuviae subcentral.

Adult female broadly ovate, broadly rounded in front, bluntly pointed behind, deeply incised on each side of the body immediately behind the cephalo-thoracic area; broadest across the metathoracic area, *i.e.*, shortly behind the lateral incision. The whole insect rigid, rather densely chitinous. Rudimentary antennae obsolete or inconspicuous. Anterior spiracles with a small group of parastigmatic pores; posterior spiracles rather inconspicuous, with no pores. Segmental divisions of abdomen marked by strong transverse folds which do not extend to the lateral margins. A few longish spiniform setae at intervals along the margins of abdomen (fig. 2, A). Pygidium not sharply defined; its centre occupied by a large reticulated area, the lacunae very irregular in size, form and disposition; no circumgenital glands; dorsal pores small, but numerous (fig. 2, B). Margin of pygidium with three pairs of lobes; the median pair larger and more prominent, bluntly conical; second and third pairs rather shallow, the apex of each nearer the inner side, more or less conspicuously notched on the free edge. There is a suggestion of a fourth lobe in the form of a sub-angular marginal prominence. Squames minute and inconspicuous; a pair between the median lobes; a second pair in the intervals between the median and second lobes; and one (possibly two) between the second and third lobes. There

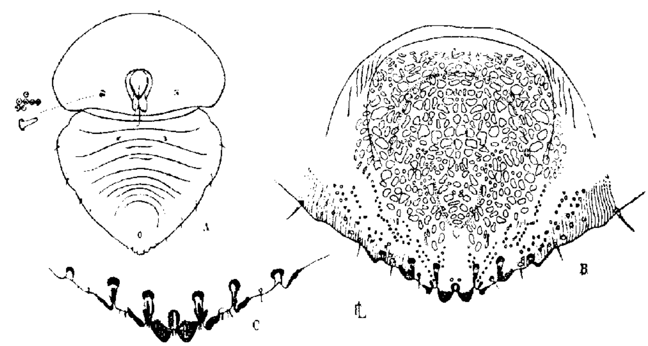


Fig. 2. *Pseudaonidia aldabraca*, sp. n.: A, adult, × 30; B, pygidium, × 150; C, margin of pygidium, × 225.

are three conspicuous crescentic incrassations, within the margin on each side, associated with short but rather stout paraphyses which extend inwards from the interval between the median and second lobes and from the inner side of the third and of the rudimentary fourth lobes. There is also a pair of short and more or less confluent paraphyses between the median lobes (fig. 2, C). Length, 1·25 mm.; greatest breadth, 1 mm.

Described from a single example.

On bark of "Bois d'Amande," Aldabra Island, Seychelles (*P. R. Dupont*).

This species is near to *P. tesseratus*, d'Emm., but differs principally in its smaller size, and in the absence of the strongly cristate lateral margins of the pygidium.

Aonidia obtusa, sp. n.

Female puparium consisting almost entirely of the enlarged nymphal pellicle, transversely oval, flat, or very slightly convex, a narrow marginal area ornamented with sutures running irregularly from without inwards and intertwining; colour varying from pale to dark brown, often thinly coated with white powdery secretion over a wide marginal area, leaving only the centre bare (fig. 3, A). Pygidium recessed,

the extremity scarcely projecting, deeply incised on each side near the base ; margin with a pair of narrow median lobes between which are two narrow squames, laterad are two squames, a lobe, three squames, and then three lobes ; squames slightly fimbriate. The basal areas (beyond the incisions) each with three prominent angular projections. There are two pairs of broad (but obscure) semilunar pores, occupying the intervals between the median, second and third lobes, and communicating with conspicuous tubular ducts (fig. 3, B). Breadth, 1–1·16 mm.; length, 0·75 mm.

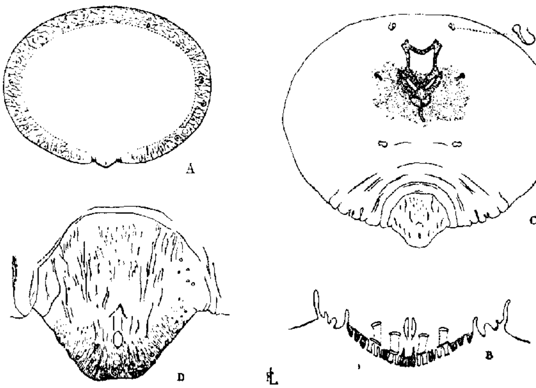


Fig. 3. *Aonidia obtusa*, sp. n : A, nymphal pellicle, × 33 ; B, pygidial margin of same, × 225 ; C, adult, × 50 ; D, pygidium of adult, × 150.

Adult female broadly ovate, 0·8 to 0·95 mm. broad, by 0·75 mm. long; abdominal segments compressed but visible. Antennae rudimentary, composed of a short curved spine situated on a tubercle. Mouth-parts strongly developed; area surrounding mouth and anterior spiracles more densely chitinised than the rest of the body (fig. 3, C). Pygidium obtuse, without a vestige of lobes or other processes ; and with several conspicuous sub-marginal pores (fig. 3, D).

On *Verschaffeltia splendida*, Seychelles (*P. R. Dupont*).

Four names may be added to the list of Coccidae already recorded from the Seychelles.

1. **Ceroplastes rubens,** Mask.

On fern (*Acrostichum* sp.). Widely distributed in the Australasian region.

2. **Chionaspis subcorticalis,** Green.

On tomatoes, Astove Island, and on *Sida* sp., Assumption Island. Hitherto recorded from Ceylon only.

3. **Pinnaspis buxi,** Bouché.

On *Pandanus seychellarum*, Felicité Island ; also on *Areca catechu*. An almost cosmopolitan species.

4. **Diaspis (Aulacaspis) flacourtiae,** Rutherf.

On *Flacourtia*. Previously known from Ceylon only.

As Rutherford published his description (Bull. Ent. Res., v, 3, Dec. 1914, p. 259) without any figures, we take this opportunity of supplying the omission (see fig. 4, A, B).

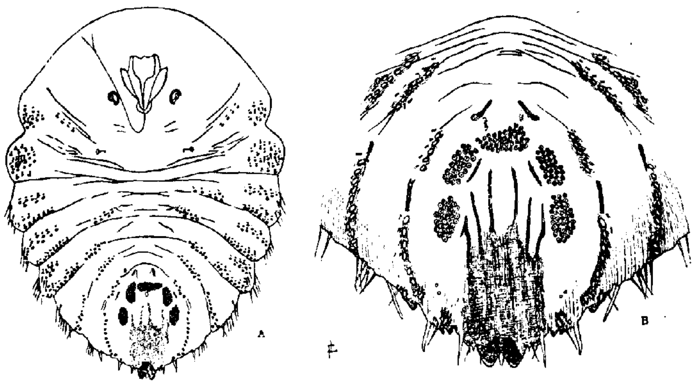


Fig. 4. *Diaspis flacourtiae*, Rutherf.: A, adult, × 50; B, pygidium, × 150.

The species differs from *pentagona*—which it closely resembles—in the relatively larger and more prominent median lobes, and in the obsolescent or very small lateral lobes of the pygidium. The dentiform first lateral lobe, which is a prominent feature in typical *pentagona*, is altogether lacking in *flacourtiae*. The pores on the lateral margins of the body are far more numerous and conspicuous in *flacourtiae*.

Rutherford makes no mention of the pathological effect upon the host-plant that is noticeable in Ceylon, where the insect causes a stimulation of growth in the sub-lying woody tissue, causing irregular and conspicuous swellings on the infested areas of the branches of Flacourtia. This effect is noticeable only upon the older and mature branches. When the smaller and younger branches are attacked, there is no such tendency to an abnormal growth.

ON THREE NEW SPECIES OF INDIAN BRACONIDAE.

By G. T. Lyle, F.E.S.

The following descriptions are based on material submitted for determination by Mr. T. Bainbrigge Fletcher, the Imperial Entomologist, Pusa, Bihar.

Family Braconidae.

Genus **Microplitis,** Först. (1862).

Microplitis similis, sp. n.

Black; palpi pale; legs testaceous, hind coxae at base and hind femora darker, apical joint of all tarsi fuscous; sides of abdominal segments 1 and 2 testaceous. Wings hyaline, nervures fuscous, stigma unicolorous, testaceous or fusco-testaceous. Antennae of male as long as body, of female one-third shorter, fusco-testaceous, scape rather darker and flagellum darker towards apex. Head and mesothorax granulate; scutellum smoother, dull; metathorax rugose, with indications of a longitudinal medial carina. Abdomen smooth and shining, only first segment feebly striolate; shield of first segment twice as long as medial breadth, slightly narrowed towards base and rounded at apex; second segment without noticeable impressed lines. Spurs of hind tibiae barely one-third as long as metatarsus. Terebra very short. Length, 2½–3 mm., expanse, 5–6 mm.

Cocoons pale tan colour, similar to those of *M. spectabilis*, Hal.

Type ♀, in the British Museum; cotypes in the Pusa Collection.

A parasite of *Agrotis ypsilon*, L., from the following localities :—

Bihar & Orissa : Pusa, 1 ♂, 4 ♀, 16.iii.1914 (type material) ; Sabour, 2 ♀ (*H. L. Dutt*). Bengal : Mokamah, 1 ♂, xii.1911 (*D. N. Pal*), and 2 ♂, 18.xii.1911 (*C. S. Misra*).

Very near *M. spectabilis*, Hal., indeed at first I considered it to be a form of that species, but the invariably unicolorous stigma and feebly longitudinally striolate first segment of the abdomen would appear to warrant its separation. *M. spectabilis*, a common European species, has the stigma determinately pale at the inner angle, the first abdominal segment minutely punctuate, and the hind and middle tarsi fuscous.

Microplitis eusirus, sp. n.

Black; palpi pale; legs rufo-testaceous (fore and middle coxae and middle femora except at apex fuscous, hind legs entirely black or blackish excepting trochanters and tarsi towards apex, which are often rufo-fuscous). Sides of first and second abdominal segments lighter in colour. Wings infumated, with the usual dark blotch under the stigma; nervures fuscous; stigma unicolorous, dark fuscous. Antennae stout, rufo-fuscous; scape rufous at base; each joint of flagellum centrally marked with an impressed band which gives the antennae the appearance of having twice as many joints as is actually the case (this character is noticeable in a lesser degree in some of the European species). Eyes pilose. Head and mesothorax densely and minutely punctuate; sutures of the mesothorax deeply and clearly impressed; scutellum rugulose. Metathorax coarsely rugose, with a medial transverse centrally angulated carina, after which the metathorax falls suddenly away (fig. 1, *a*). Abdomen smooth and shining; shield of first segment elongate, three times as long as medial breadth, with parallel sides, slightly widened at base, and

truncate at apex (fig. 1, *a*), apical tubercle not prominent. Spurs of hind tibiae pale, less than one-third as long as metatarsus. Terebra very short. Length, $3\frac{1}{2}$–4 mm., expanse, 7–8 mm.

Type ♀ in the British Museum; cotype in the Pusa Collection.

BIHAR & ORISSA: Pusa, 1 ♂, 2 ♀ and fragments of 2 others reared from *Achaea janata*, L., 20.ix.1912 (*H. L. Dutt*).

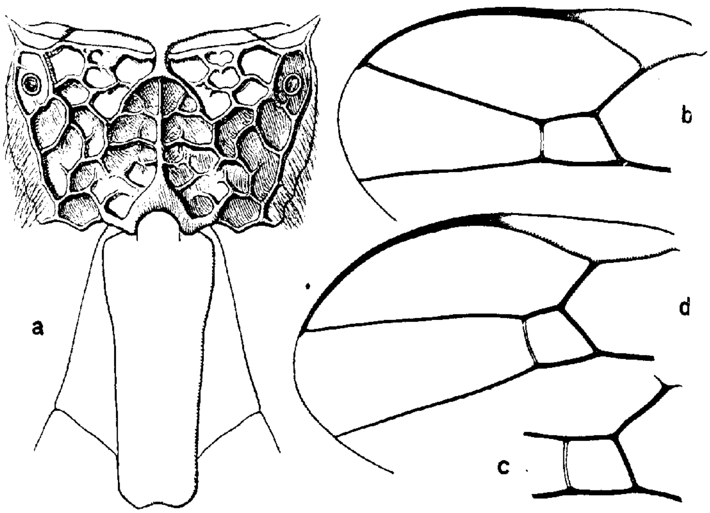


Fig. 1 (*a*). Propodeon and first abdominal tergite of *Microplitis eusirus*, sp. n., ♀; in the propodeon only the major reticulations are shown; the point of view is at right angles to the median carina, and the dorsal surface (unshaded) is seen considerably foreshortened; only the outline of the plate on the 1st tergite is indicated.

(*b*). *Rhogas* (*Heterogamus*) *percurrens*, sp. n., ♀; detail of wing.

(*c*). *Heterogamus dispar*, Curt., ♂; detail of wing.

(*d*). *Heterogamus dispar*, Curt., ♀; detail of wing.

Genus **Rhogas**, Nees (1818).

The following species is, formally at least, referable to *Heterogamus*, Wesm. (1838), but the difference between the first and second abscissae of the radius is so slight that the insect might with almost equal propriety be placed in *Rhogas*, Nees (fig. 1, *b*). The genotype of *Heterogamus*, Wesm. (*H. dispar*, Curt.) is a rare and extremely distinct species, and quite possibly *Heterogamus* may be a valid genus; but if so, it is not yet properly understood and its real differentiae have not been fully signalised. I have not had before me sufficient material of the genotype to satisfy myself on this point, and for the present treat *Heterogamus* as a subgenus. It can deserve no higher rank than this if its only criterion be the ratio between the first and second radial abscissae.

Rhogas (Heterogamus) percurrens, sp. n.

♀.—General colour of antennae,* body and legs pale ferruginous. The ocellar triangle, but not the ocelli themselves, blackish. Mesonotum with a broad longitudinal faintly infuscated band inside each notaulus and two narrow short ones on the mid lobe anteriorly. Wings with costa, including basal three-fifths of the stigma, concolorous with the body, apical two-fifths of stigma infuscated. Nervures mainly darkened, but the second abscissa of the cubitus very pale. Abdomen a little darkened posteriorly from about the middle of the fourth tergite. Venter all pale; sheath of ovipositor blackish brown. Antenna with joints subequal, about one-third longer than broad. Thorax with transverse sulcus at base of scutellum crenulate with about eight large punctures or pits. Sides of scutellum with seven to eight short, stout, parallel ridges. Metanotum, apart from the usual divisions, smooth. Propodeon, in the type, with the median keel not completely percurrent, reaching back only to about two-thirds; the surface on each side of the keel irregularly rugulose; spiracle moderate, oval, a little over twice its length from the anterior edge.

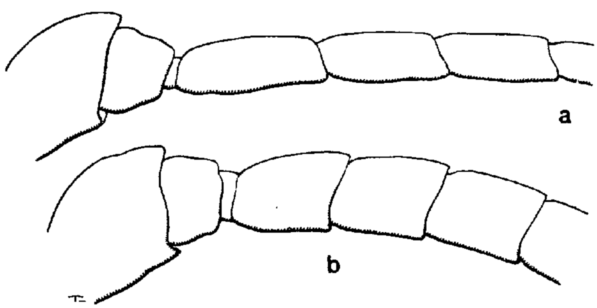


Fig. 2. Basal portion of antenna of (*a*) *Heterogamus dispar*, Curt.; (*b*) *Rhogas* (*Heterogamus*) *percurrens*, sp. n.

In the wings (fig. 1, *b*) the second cubital cell is a little, but quite perceptibly, narrowed distally, the second abscissa of the radius being slightly inclined to the third abscissa of the cubitus; first intercubital nervure and second abscissa of the radius subequal, the latter again much longer than the second intercubital. The radius and cubitus strongly divergent distally. The stigma distinctly broad.

Abdomen with the median keel percurrent to the posterior edge of the third tergite, sharply defined throughout its course, though broader on tergite one. Throughout its course the mid keel is flanked by numerous subparallel longitudinal ridges or rugae, these being continuous from tergite to tergite and extending even to the anterior or basal one-third of tergite 4. The first three tergites are rigid, and the sutures (especially the first) deep and distinct. The second suture (between two and three) might almost be described as crenulate, as the sulcus is cut into little pits by the percurrent rugae. Beyond the basal one-third of the fourth tergite the surface is smooth; only the smooth edge of the fifth tergite is visible.

Length just over 5 mm.; alar expanse, 9 mm.

Type a ♀ in the British Museum.

* In the single antenna preserved, which is complete up to the 23rd joint (21st of the funicle) the colour is uniformly pale ferruginous without any suggestion of banding.

BIHAR & ORISSA: Pusa, a unique ♀ reared from *Achaea janata*, L., 7.x.1912 (*C. R. Dutt*).

R. percurrens sp. n., has a strong but probably superficial resemblance to *Heterogamus dispar*. So far as colour is concerned the resemblance is to the ♂ of that species. In colour, however, *dispar* is notoriously variable. It is possible that the darkening of the thorax and abdomen in *percurrens* owes something to the drying up and discoloration of the underlying musculature of these regions.

H. dispar is easily separated from the present insect (*a*) by the basal antennal joints, which are at least twice as long as broad (fig. 2); (*b*) in the wings (fig. 1, *c*, *d*), the radial cell is longer and more acute, the second cubital cell "higher" (♀, ♂), the second abscissa of the radius being just shorter (♀) or much shorter (♂) than the first intercubital. The same abscissa is again equal to (♀) or much shorter than (♂) the second intercubital. The radius and cubitus are less abruptly divergent distally and the stigma is narrower. In the abdomen the median keel is percurrent to the posterior margin of the second tergite only in the material available for examination.

THE PTINID BEETLE, *TRIGONOGENIUS GLOBULUM*, SOLIER, BREEDING IN ARGOL.

By Hugh Scott, M.A., Sc.D., F.E.S.,

Curator in Entomology, University of Cambridge.

In March 1920 my attention was called by Dr. F. W. Dootson, University Lecturer in Chemistry, to the fact that a beetle was breeding in numbers in a jar of argol in the Chemical Laboratory of Cambridge University. The insect proved on examination to be the introduced Ptinid, *Trigonogenius globulum*, Solier,* a form related to the household insect, *Niptus hololeucus*, to which it bears at first sight a slight resemblance.

Argol is the crust or deposit which separates out in barrels of new wine. It contains a high percentage of cream of tartar (potassium bitartrate), and most of the pure stock of that chemical is prepared from it. The argol in which the beetles were living was found to contain about 80 per cent. of potassium bitartrate. The argol was a purplish-red powder of close consistency, and it came to the Chemical Laboratory from London in a bag in 1913. It was placed in an earthenware jar, tightly corked with a wide cork bung. The powder did not quite fill the jar, but a very small air-space was left at the top.† I am assured that the jar was not opened from the time the powder was put in till early in 1920, when the argol was found to be full of adults and larvae of the *Trigonogenius*. The cork, which I have twice examined, has not been bored through or damaged by insects in any way, and it fits so closely that it is almost impossible that the beetles can have got into the jar down the side of the cork; nor have they been noticed anywhere else in the laboratory. Probably, therefore, some of the insects were in the argol when it came to the laboratory and have continued breeding in it all these years. No other kinds of insects were found in the argol. I am indebted to Dr. Dootson for most of the foregoing particulars and for samples of the infested chemical.

That the beetles were nourishing themselves, not exclusively on the 80 per cent. of potassium bitartrate, but at any rate partly on some of the ingredients forming the other 20 per cent. of the argol, seems to be indicated by the following experiment, carried out at Dr. Dootson's suggestion. Some of the insects were placed on the surface of about two inches depth of pure cream of tartar in a wide-mouthed corked bottle, with plenty of air-space between the surface of the chemical and the cork; 32 adults and 15 larvae were placed in this on 12th March 1920. Three and a half hours later almost all the larvae had burrowed down into the white powder, but the adults were still on the surface and showing signs of discomfort. Next day all the larvae but one were below the surface, and also about 23 of the adults; the remaining adults were still on the surface and one was dead. No further observation was made for nearly three weeks, when (on 1st April 1920) about 14 adults and one larva were seen to be on the surface, while the other 18 adults and 14 larvae had all burrowed some way down into the cream of tartar, and several burrows were visible against the glass sides of the bottle. The bottle was not examined again for nearly a year, when (on 15th March 1921) its contents were turned out, and all the insects were

* Described by Solier in C. Gay's "Historia de Chile," iv, 1849, p. 464. I have retained Solier's original spelling of the specific name, though in some later works *globulum* is altered to *globulus*, which is probably more correct. Solier called the species *globulum*, but at the same time named a variety of it *globosus*. Why he gave the former name the neuter ending is difficult to say. He may have intended *globulum* to be a noun, but in several dictionaries of classical and late Latin which I have seen, the only form of the word is a late Latin noun, *globulus*.

† In some of the argol which was put into a glass-stoppered bottle, filling it up to the stopper and leaving no air-space, all the insects died.

found to be dead; there were four adults on the surface and 34 adults below, and remains of about eight larvae were found. It will be noticed that the adults were six more in number than those placed in the bottle the year before, proving that some of the larvae had succeeded in reaching the adult state; most of them when put in were fairly big. But the attempt to start a culture breeding in pure cream of tartar failed. It should be mentioned that no moisture was supplied, but neither was it, of course, in the original jar of argol, which was however far larger and contained a very much greater bulk of chemical than the bottle used in this experiment.

In the original jar of argol the insects were still present in large numbers in April 1921. Series of adults and larvae have been preserved, but I have found only one pupa, though samples of the argol have been looked through on several occasions. This single pupa was found at about the end of March 1921. Mr. Michael G. L. Perkins, who placed some of the argol in a vessel and kept the beetles present in it under observation, obtained about 30 pupae in July 1920. He has also started cultures of the insect in certain food-stuffs such as oatmeal and raisins, and, so far as his observations have gone, he considers that the generations succeed one another more rapidly in these food-stuffs than in the argol, in which substance the insects appear to be reproducing themselves only at the rate of about one generation a year. He hopes to publish the results of his investigations in the future.

The larva pupates in a cocoon formed of a feltwork of fine threads, secreted by itself. The cocoon is not lined, and the feltwork is easily pulled apart with needles into a loose tangle of threads. The feltwork appears whitish when the argol powder is shaken away from it. Under a high power ($\frac{1}{8}$-inch objective) the threads are quite colourless and transparent. Many full-fed larvae, pupae, and adults have been found in these cocoons by Mr. Perkins and myself. Mr. Perkins sifted the argol, to remove all foreign material from it, before he placed his observation culture of the insects in it, thereby proving that the threads are actually produced by the larvae. He thinks that other feltwork is produced in the burrows, besides that actually used in the construction of the cocoons.

Trigonogenius globulum was originally described from Chile, but is very widely distributed. In M. Pic's Catalogue of Ptinidae (1912, Col. Cat., part 41, p. 9), it is recorded from various parts of North and South America, Tasmania, and England. Most of the known species of the genus are, according to the Catalogue, known from Central or South America, and several of them are not known from elsewhere, so that region may be their native home. Fowler & Donisthorpe (Col. Brit. Isl., vi, 1913, p. 147) state that it has occurred in corn mills and granaries in various industrial centres in England. Champion (Ent. Mo. Mag., 1918, p. 40) records it as having been found under timber and among wood-shavings in London, in company with *Ptinus tectus* and *Niptus hololeucus*: and Potter (*op. cit.* 1919, p. 88) records it from old cotton mills near Manchester, where it was attracted to baits of sugar It is not mentioned in Reitter's " Fauna Germanica: Die Kafer " nor in the addenda at the end of the last volume of that work (Vol. V, 1916), so it had evidently not occurred in Germany up till 1916 within the knowledge of the writers of that book. I have not searched the literature further. *Ptinus tectus* and *Niptus hololeucus*, the members of the same family mentioned above, are, like *Trigonogenius globulum*, found in various stored products. *Ptinus tectus* further resembles it in being almost cosmopolitan in range. It may be recalled that larvae and adults of *Niptus hololeucus* have recently been found in cocoa powder from a south German chocolate factory (Rev. Appl. Ent., A.ix, 1921, p. 66).

A REVISION OF THE GENUS *LOCUSTA*, L. (= *PACHYTYLUS*, FIEB.), WITH A NEW THEORY AS TO THE PERIODICITY AND MIGRATIONS OF LOCUSTS.

By B. P. Uvarov, F.E.S.,

Assistant Entomologist, Imperial Bureau of Entomology.

Contents.

I. Introductory.

The genus *Locusta*, L. (= *Pachytylus*, Fieb.) includes two of the most destructive swarming locusts of the Old World: the widely distributed *L. migratoria*, L. (with *L. danica*, L., and *L. migratorioides*, Rch. & Frm., as its forms; see below), and the South African *L. pardalina*, Walk. The literature on the economics, biology and especially on the means of control of these locusts is enormously extensive, but at the same time their systematic arrangement is in considerable confusion, and extremely contradictory opinions as to the mutual relationship of the different so-called species exist among specialists. As a direct consequence of this, the field research and control work of economic entomologists is apt to suffer through the difficulty in getting a particular species properly named,* and thus it is often impossible to make a comparison of the records as to the biology and control of the same species in different countries.

Having had the opportunity of conducting, during the years 1911–14, extensive field research work and control work on *L. migratoria* in the northern Caucasus (Russia), and being a systematist, I could not fail to see at once that only very little progress could be made without a definite solution of the question of the inter-relation between *L. migratoria* and *L. danica*, which latter has been accepted by many authors as a species distinct from *migratoria*, and as conspecific with it, by others. The same question arose before the Turkestan Entomological Station (in Tashkent) as soon as its staff began to work on *L. migratoria*.

Apart from my field work, which involved the study of immense series of living specimens in all stages, I endeavoured to gather all reliable information as to the distribution and local, individual and annual variability of *L. migratoria* and *danica* in different parts of their range, and owing to the support of entomologists and institutions throughout Russia and elsewhere, I managed to concentrate in my hands extremely rich materials from the following sources: Turkestan Entomological Station (V. j. Plotnikov); Astrakhan Entomological Station (N. L. Sakharov); Natural History Museum in Kherson (J. K. Pachossky); Zoological Museum of the Moscow University (Prof. J. Kozhevnikov); Caucasian Museum in Tiflis; Zoological Museum in Berlin. The following persons also contributed very valuable materials and information: Prof. J. Shtchelkanovzev, E. Jatzentkovsky, V. Artsimovicz

* See, for instance, the interesting paper on the biology and control of the Malayan locust by H. C. Pratt (Bull. No. 27, Dept. Agric. Fed. Malay States, 1915), who states that "many attempts to identify this Malayan locust have been made and correspondence has been entered into with authorities throughout the world, but without success." He has been compelled to call the insect, simply, *Pachytylus* sp.

N. Ikonnikov, V. Boldyrev, L. Moritz, H. C. Pratt (Government Entomologist, Federated Malay States), and many others. Thanks to this generous help, I was able to come to certain conclusions on the question of *migratoria-danica* already in 1915, but the War and other circumstances prevented me from publishing a paper on it. When I arrived in London in 1920 and studied the exotic representatives of the genus *Locusta*, I felt the necessity of revising my previous work and extending its limits so as to include in it all known species and forms of the genus. This plan proved to be a very productive one, since a far more definite idea as to the inter-relations of different "species" has been thus reached. A study of the South African *L. pardalina*, Walk., has been also accomplished in the British Museum, but I could not do much with museum material only, and the most effective help in this respect has been rendered me by the Division of Entomology, Pretoria, and especially by Mr. J. C. Faure, who has sent to the Imperial Bureau of Entomology at my request extensive series of specimens, together with most valuable information.

With regard to the biological observations here recorded, it is only thanks to the help rendered me by my assistants, G. Vinokurov, Th. Gliniuk, the late G. Pirkovsky, and others, that I could collect the necessary facts. My most sincere thanks are due also to all the above-mentioned persons and the heads of institutions who have lent me material and supplied information.

II. On the Generic Name *Locusta*, L.

The Linnean genus, *Gryllus Locusta*, includes 20 different species of locusts and grasshoppers, belonging to about as many modern genera. There is no wonder, therefore, that much controversy arose around the question as to the species to which the Linnean name *Locusta* must be restricted now. This question becomes still more complicated owing to the fact that Geoffroy (Hist. Ins. i, p. 396, 1762) applied the name *Locusta* quite erroneously to the long-horned katydids (now called TETTIGONIIDAE, or, wrongly, PHASGONURIDAE), and has been followed in this mistake by all continental European authors, till quite recently. There is, however, no doubt, that Linné, who adopted the name *Locusta* from the old Roman writers who applied it to swarming locusts, intended it to include those insects and the short-horned grasshoppers generally. This view was accepted long ago by British authors, and W. E. Leach (Edinburgh Encyclopaedia, ix, pt. 1, p. 120, 1815), though using *Locusta*, Geoffr., for katydids, used at the same time *Gryllus Locusta*, L., for *migratoria*, L., the latter being the only species described by him under this genus, and, therefore, he actually has fixed it as genotype of *Locusta*, L. A few years later on, Samouelle (Entomologist's Useful Compendium, p. 218, 1819) followed Leach in restricting the genus *Locusta* to *migratoria*, but he calls it wrongly *Locusta*, Leach, not Linné. Stephens in 1829 (Cat. Brit. Ins., i, p. 301, No. 2, sp. 3315) merely repeats Samouelle's interpretation of the genus. Even if we do not accept the genotype of *Locusta*, L. cited in 1815 by Leach, we shall find a most formal fixation of it in the British Entomology of Curtis (iii, pl. 608, August 1836), who in describing *Locusta christii*, Curtis (=*danica*, L.) said positively: "Type of the genus, *Gryllus migratorius*, L." All subsequent works on the same subject are, thus, of no importance, and the generic name *Pachytylus*, Fieber, proposed in 1853 (Lotos, iii, p. 121) for *migratoria* and *danica* is a pure synonym of *Locusta*, L. The proposal of Rehn (Canadian Entomologist, xxxiii, 1901) to restrict the genus *Locusta*, L., to *apricarius*, *viridulus* and *biguttulus*, which are included now in the genera *Stauroderus* and *Omocestus*, as well as that of H. Krauss (Zool. Anz., xxv, 1902, p. 539), who regarded *tatarica*, L., as the genotype of *Locusta*, cannot be accepted in view of Curtis' work, which was overlooked by both these authors.

It is, therefore, in full accordance with what Linné meant by his genus *Gryllus Locusta*, as well as with the formal laws of nomenclature, that *migratoria*, L., must be regarded as the genotype of *Locusta*, L.*

Not less than 16 " species " have been described by different authors as belonging to the genus *Locusta*, L. (=*Pachytylus*, Fieb.). This number, however, has been reduced already by earlier revisers, who synonymised many species; but W. F. Kirby in his Catalogue (Syn. Cat. Orth., iii, 1910, pp. 221–231) still mentioned seven distinct species. My investigations, however, have clearly demonstrated the variability of the species of *Locusta* to an extent far greater than might have been anticipated, and my conclusion, which will be fully proved presently, is that only two species can be distinguished, namely, *migratoria*, L., and *pardalina*, Walk., but the latter differs from *migratoria* in so many important characters that a new genus is described below (p. 162) to include it, which I propose to call *Locustana*, g. n.

III. *Locusta migratoria*, L., and its Forms.

Morphological Characters and Variability of *migratoria* and *danica*.

These two forms, if typical examples are studied, seem to be quite distinct from each other in many morphological characters, and may be regarded, as has been done by most authors, as two independent species. On the other hand, every extensive collection includes specimens of *Locusta* that cannot be identified with certainty with either *migratoria* or *danica*, but seem to represent intermediate forms. This fact induced many authors to regard *migratoria* and *danica* as but extreme individual aberrations of the same species.

In studying this question I tried, first of all, to analyse carefully and impartially† all the external morphological characters of both forms, as given by different authors, studying them on as extensive a series of specimens as possible.

After excluding all characters that at once proved to be too indefinite or simply incidental, the following summary of differences between typical *danica* and *migratoria* has been obtained :—

L. migratoria (fig. 1, C, D, E.)	*L. danica* (fig. 1, A, B.)
Vertex convex, with a median longitudinal keel; fastigium separated from frontal ridge by an angular transverse keel.	*Vertex* flat, without median keel; no transverse keel separating fastigium from frontal ridge.
Pronotum relatively shorter and broader in metazona, with a distinct construction before the middle; fore margin rounded; hind angle rounded; median keel low, in profile straight or even concave.	*Pronotum* relatively longer and more compressed laterally, without or with but feeble constriction before the middle; fore margin angulately prominent; hind angle acute; median keel high, tectiform, convex in profile.
Elytra‡ relatively longer.	*Elytra* relatively shorter.
Hind femora relatively shorter.	*Hind femora* relatively longer.

* I am much indebted to Mr. J. H. Durrant for the help he has generously given me in the solution of this question.

† I must candidly confess that when starting my work I had only a very modest intention—to find out characters for separating *migratoria* and *danica*, which I assumed beforehand to be distinct specifically. The facts quickly destroyed my preconceived opinion and compelled me to work deductively.

‡ This important and rather striking difference between *migratoria* and *danica* was first noted by the artist of the Zoological Museum in Petrograd, Miss O. M. Somina, who made drawings of both insects for Mr. I. Shevyrev, and the latter drew my attention to it.

A study of long series of both forms showed that the differences in the vertex, as given above, are quite unreliable, since the median keel of the fastigium proved to be absent in one per cent. of the specimens of *migratoria*, as well as in about 7 per cent. of *danica*; the transverse keel was found in 80 per cent. of *migratoria* and in about 47 per cent. of *danica*; as for the flatness or convexity of the vertex, it is too indefinite a character to be reliable. The only trustworthy characters are, therefore, the shape of the pronotum and the relative length of the elytra and hind femora. In order to avoid, as far as possible, any subjective judgment, I have expressed these characters in terms of actual measurements. This is quite simple in the case of the elytra and femora, since there exists an inverse proportion between their lengths, and we may simply express the length of the femora as a percentage

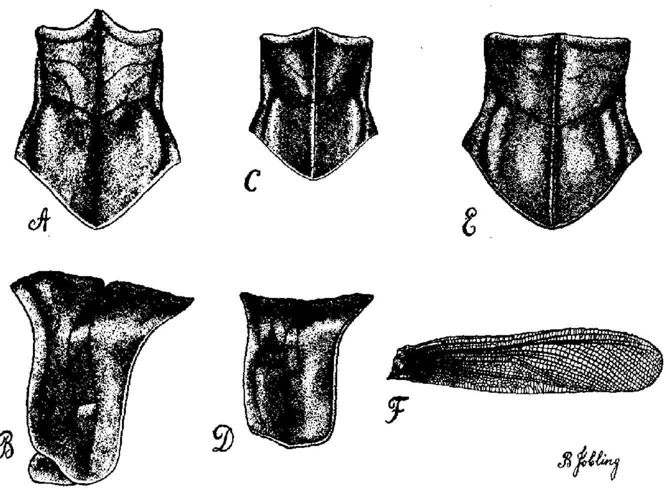


Fig. 1. *Locusta migratoria*, L.: A, B, phase *danica*, L., ♀, Turkestan; C, D, ph. *migratoria* ♂, progeny of preceding specimen; E, ph. *migratoria*, typical ♀, Astrakhan; F, elytron. Elytron natural size, remainder × 3.

of the length of the elytra. As for the shape of the pronotum, numerous measurements have shown that the width of the metazona (measured between the shoulders, *i.e.*, at its widest), if expressed as a percentage of the length of the whole pronotum (along the median keel), gives the best and most reliable impression of the actual shape. The relative height and form of the median keel, which seem to be excluded from consideration by using this proportion, is but a secondary character which depends entirely on the relative length and width of the pronotum. If we imagine that the short and broad pronotum of *migratoria* undergoes a lateral compression, we may expect it to become longer, and its median keel higher and convex, especially in the metazona, which should be most influenced by lateral compression; there is no doubt, therefore, that the shape of the median keel must be, and actually is, subject to changes correlated with those of the length and width of the whole pronotum.

Though it would be interesting and useful to give individual dimensions of all the specimens measured, I refrain from doing so in order not to encumber this paper with many pages of figures. I will give, therefore, only a general table of the chief results obtained, which will be enough for our conclusions (see Table I).

TABLE I.

Showing Dimensions of different Phases of L. migratoria, *L.*

	Number of Specimens Examined.				Pronotal Proportion.*				Femoral Proportion.†			
	Total.	*migratoria.*	*danica.*	transitional.	Maximum.	Minimum.	Extent of Variation.	Average.	Maximum.	Minimum.	Extent of Variation.	Average.
1. All *migratoria*	171	171	—	—	0·89	0·71	0·18	0·80	0·53	0·40	0·13	0·46
2. All *danica*	166	—	166	—	0·85	0·59	0·26	0·72	0·63	0·43	0·20	0·53
3. Palaearctic *danica*	103	—	103	—	0·84	0·59	0·25	0·72	0·63	0·43	0·20	0·52
4. Extra-Palaearctic *danica* ..	63	—	63	—	0·85	0·66	0·19	0·74	0·60	0·46	0·14	0·55
5. Stavropol province, 1912 ..	25	25	—	—	0·87	0·71	0·16	0·79	0·53	0·42	0·11	0·45
6. do. do. 1913 ..	32	19	8	5	0·87	0·66	0·21	0·77	0·53	0·41	0·12	0·47
7. Valley of R. Kuma, 1913 ..	28	23	4	1	0·87	0·64	0·23	0·78	0·53	0·41	0·12	0·46
8. do. do. 1914 ..	36	25	8	3	0·87	0·65	0·22	0·76	0·54	0·42	0·12	0·48
9. Lac Vshivoye, 1912	11	10	1	—	0·80	0·74	0·06	0·78	0·48	0·41	0·07	0·45
10. do. do. 1913	8	2	4	2	0·80	0·69	0·11	0·75	0·51	0·48	0·03	0·49
11. Konstantinovka, Stavropol prov. 1911	10	—	6	4	0·77	0·68	0·09	0·72	0·55	0·45	0·10	0·50
12. Kalaus, Stavropol prov., 1913..	9	7	—	2	0·89	0·73	0·16	0·79	0·49	0·45	0·04	0·47
13. Valley of R. Terek, 1913 ..	26	22	—	4	0·87	0·76	0·11	0·80	0·50	0·42	0·08	0·46
14. Valley of R. Syr-Darya, 1912..	16	16	—	—	0·89	0·74	0·15	0·80	0·50	0·40	0·10	0·45
15. Mangishlak, Caspian Sea, 1911	10	10	—	—	0·87	0·73	0·14	0·80	0·46	0·43	0·03	0·45
16. Korea, 1900	8	—	8	—	0·78	0·68	0·10	0·73	0·60	0·52	0·08	0·55
17. Smyrna	14	—	14	—	0·84	0·67	0·17	0·75	0·63	0·51	0·12	0·55
18. Azores	20	—	20	—	0·85	0·69	0·16	0·75	0·60	0·52	0·12	0·57
19. Congo	9	—	9	—	0·82	0·68	0·14	0·75	0·59	0·50	0·09	0·54
		migratorioides.										
20. S.W. Nyasa	4	—	—	—	0·94	0·83	0·11	0·86	0·46	0·42	0·04	0·44
21. Lagos	5	—	—	—	0·85	0·78	0·07	0·86	0·46	0·42	0·04	0·44

* Relation of the shoulder width to the length of pronotum.
† Relation of the length of hind femur to that of the elytron.

When studying the first two lines of the table we see that individual figures for specimens of both forms are highly variable. Owing to this variability there is no interval between a row of figures for *danica* and that for *migratoria*, which partly overlap each other. This accounts for the fact that a curve representing the variability of the pronotal proportion (fig. 2) in both forms together has only one maximum; it seems to indicate that, so far as the shape of the pronotum is concerned, there is no possibility of regarding *migratoria* and *danica* as different species, or even as two distinct forms of the same species. The curve of variability of the femoral proportion (fig. 3), on the contrary, has two separate maxima, as if the material studied could be divided into two distinct groups, be these species or units of lower taxonomic value.

As for the average figures for both forms, they are also quite distinct and even not too near each other; the maxima and minima are also more or less characteristic for each form. It may be noted that *danica* is more variable than *migratoria*, the extent of variation in it amounting to 35 per cent. of the average figure in the case of the pronotal proportion and about 38 per cent. for the femoral; while the corresponding variations in *migratoria* are only about 29 and 26 per cent. respectively. The next interesting point is that specimens of *danica* from the Palaearctic region are far more variable than those of extra-Palaearctic origin.

All subsequent lines in the table (from the fifth downwards) give figures each for a number of specimens from one locality and taken mostly at the same time, without any selection, and regardless of the forms to which they belonged, in order to obtain an impression as to proportion of both forms and of the extension and direction of variability in each lot separately. We shall have to deal with these lines in more

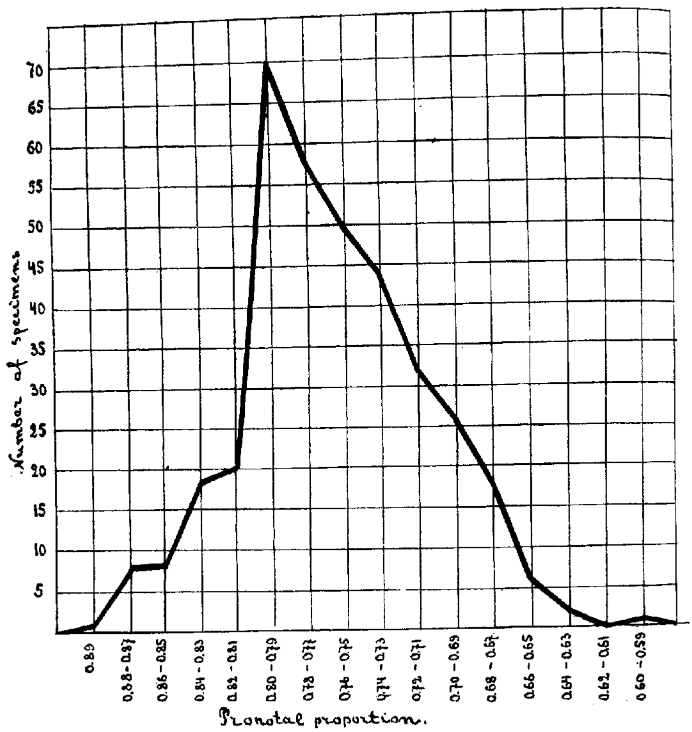


Fig. 2. Diagram showing range of variation in the pronotal proportion in 358 specimens of *Locusta migratoria*, L.

detail afterwards, but it may be noted that the range of variation is rather different not only in series of different origin, but also in lots taken at the same place in two successive years, *i.e.*, from swarms which may be regarded as two successive generations. Examples of this kind will be found in lines 5 and 6, and 7 and 8, of Table I.

If we summarise the results of this attempt at a statistical study of the morphological interrelations between *migratoria* and *danica*, they seem to be rather contradictory,

r, anyway, do not help much towards a definite solution of the question whether hese two forms are really distinct or not.

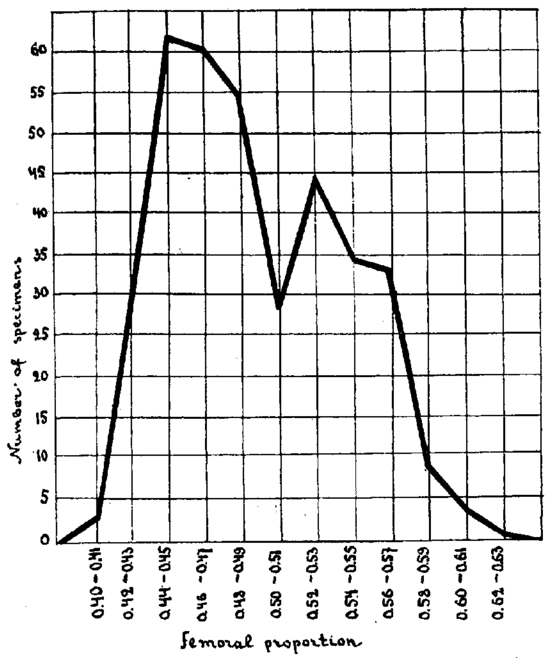


Fig. 3. Diagram showing range of variation of the femoral proportion in 358 specimens of *Locusta migratoria*, L.

Characters drawn from the Genitalia.

The late Dr. N. Adelung, of the Petrograd Zoological Museum, who tried long ago to solve the problem of *migratoria* and *danica*, suggested to me, when I began to work at it, that the anatomy of the genitalia, especially those of the males, might give definite proof of the specific difference of these insects, which he himself believed to be distinct. He even prepared some rough sketches of the male genitalia of both forms, which, in his opinion, showed that they may be separated without much difficulty by the shape of the penis. He gave up his work, but handed over to me his sketches and photographs. After a careful examination of these, and a comparison with several good preparations, I am fully convinced that Dr. Adelung's conclusion is not right; since the seeming difference between the penis in *migratoria* and *danica* in his preparations (so far as I know, he dissected only one specimen of each form) depends entirely on the fact that he studied the whole genital apparatus without dissecting it, and the somewhat different shapes shown in two of his drawings are merely the result of covering tissues having been more completely removed in one case than in the other.

My studies show, on the contrary, that the male genitalia of *danica* and *migratoria*, which are composed of several very complicated pieces (see fig. 7, A, B, C, D), are rather constant in the shape of the different parts, and though slight variations do occur, these are in no way connected with the external differences, and afford no reliable criterion for separating the two forms.

Colour Characters in Adults and Larvae.

In regard to the general coloration, as well as the pattern of the different parts, adults of both *danica* and *migratoria* are rather variable, and no definite colour characters can be given for separating them. Generally speaking, however, the extent of the colour variability in *migratoria* is far less than in *danica*, and there is a well-marked tendency in the former to a paler general coloration and less defined markings; especially noteworthy is the fact that the hind tibiae in *migratoria* are never red, save quite exceptionally.

The coloration of *danica* is generally far more variable, with the evident prevalence of bright green forms; dark brown, even almost black forms occur also not infrequently, while the pattern is very variable but always well pronounced. The hind tibiae in *danica* are very often red, but this character is far from being constant, since often quite typical specimens have the hind tibiae pale or greenish.

While, as above stated, the coloration of the adults is of but very little use for separating the two forms, it is quite otherwise in the case of larval stages, in which there is a very striking difference. In fact, it is almost impossible to find any definite type of coloration of the larvae of *danica*, which vary enormously; uniformly green forms are most common, but fawn, grey, brown, and even black ones may be met with together. Quite the opposite is the case in *migratoria*, in which each larval stage exhibits quite constant colour characters. Their coloration presents a combination of black and orange-red (or yellow), the earlier stages being almost entirely black, while orange, or yellow, appears first in the third stage, extending gradually after each subsequent moult.* There is, of course, a certain variability in the shade of the colours, but as a rule larvae of *migratoria* of the same stage are all practically identically coloured; and it is important to note that this type of coloration never occurs in the larvae of *danica* in spite of the wide range of variation in the latter.

Sexual Dimorphism.

There is a well-pronounced sexual dimorphism of the general dimensions in *danica*, the males (adults) being distinctly smaller than the females; average figures of the length of the body, elytra, etc., for males differ from corresponding figures for females by about 20 per cent. of the latter, so that one may separate the sexes by the size only, provided that the specimens are all taken at the same place and time. As for the proportions between the dimensions of the different parts of the body, they are not connected with the absolute dimensions and remain the same in both sexes.

In *migratoria* no such apparent difference in size between the sexes is observed, the males being on the average smaller than the females by only some 4 per cent. of the figures for the latter; and males of larger size are indistinguishable from females so far as the dimensions are concerned. Since the absolute dimensions in both *migratoria* and *danica*, especially in the latter, are rather variable, they are of very little value for separating these forms.

---

* I do not propose to give a detailed description of the larval stages of *migratoria*, since this has been done more than once by different authors; very good descriptions and fairly good coloured figures have been given by H. C. Pratt (Dept. of Agric. Feder. Malay States, Bull. No. 24, 1915).

Another case of sexual dimorphism is observed in the adults of *migratoria* during the period of copulation and concerns the general coloration.* The males gradually assume a bright yellowish general coloration, most pronounced on the pronotum, while the females become more dull coloured, the pronotum turning to dark brown. These changes doubtless depend on some physiological processes connected with the maturation of the sex products. As for *danica*, it is not yet known whether it exhibits any change of coloration during adult life.

Biology.

While *danica* seems to have no marked preference for any particular type of locality for its permanent habitation, except vast waterless tracts and forests, *migratoria*, on the contrary, has strictly defined permanent breeding grounds. In Russia, where much attention has been paid by entomologists to the biology of *migratoria*, its breeding grounds are all confined to the basins of the Caspian and Aral Seas and of Lake Balkhash, and more definitely to the deltas of the rivers discharging into them, namely, the Volga, Ural, Kuma, Terek, Arax, Syr-Darya, Amu-Darya, Ili, etc. These deltas, as a rule, extend over vast areas irrigated by numberless channels which change their course almost every year, some of them forming temporary pools and small lakes. The shores of these channels and even the beds of the shallower ones, as well as all the less elevated portions of land separating the channels from each other, are covered with a dense growth of the gigantic cane, or reed grass (*Phragmites communis*, Trin.), sometimes 10–15 feet high, which form almost impenetrable jungles extending over hundreds of square miles. These reed-beds, however, are not uninterrupted, since many of the islands between the channels are more elevated above the level of the water than is suitable for the growth of the reeds, which require a very damp soil. The soil of such islands mostly contains a large proportion of sand, and a peculiar flora of low, not very dense, mesophilous and xerophilous grasses covers them. It is in such localities that *migratoria* lays its eggs, as a rule,† while its larval swarms wander all over the valley, penetrating through the reed-beds, and even swimming across the streams. The leaves of the reeds, which contain a very large percentage of silica, represent the most preferred food of the larvae. The climatic conditions in these reed-beds are very peculiar and differ very much from those prevailing in the adjoining steppes and deserts; since the waters of the river are there spread over a vast surface, the evaporation is very extensive, and the damp, hot air amidst the reeds at midday vividly recalls the tropics.

All the sufficiently investigated breeding grounds of *migratoria* in Russia are of the character described, and nowhere except in these grounds does this insect live and breed permanently. Naturally the locusts are not always equally numerous in the breeding regions, and in the years of minimum development only a few swarms or even but single individuals may be found; during the next few years their number increases, the swarms become more and more dense, and a maximum is in this way attained.

The newly-hatched larvae collect in small groups, each of which is, as a rule, formed by larvae hatched from one egg-mass. These groups soon begin to move irregularly to and fro; if two groups meet they form one larger group and in this way larval swarms are formed, and their movements become more and more regular. Most authors regard want of food as the direct cause of these movements, but this explanation is entirely wrong, at least so far as concerns *Locusta migratoria* and

* This fact was first observed by my assistant, Mr. Th. Gliniuk, in 1912, in Stavropol province, and was recorded by me in the paper: "The Fight against Locusts in the Government of Stavropol in the years 1907–1912," St. Petersburg, 1913 (in Russian).

† The matter is really more complicated than this, since the selection of spots for oviposition is usually closely connected with the more minute character of the soil and vegetation.

Dociostaurus maroccanus, Thunbg., both of which I have studied for several years. It is true that when the vegetation is very rich, the rapidity and extent of movement of larval swarms is less than in the case of a sparse vegetation, but larvae *will* move, however densely overgrown with their most favourable food-plants the place may be. Moreover, in both the species referred to, the larvae do not feed during movement, save in some exceptional cases, as, for instance, when a swarm has previously wandered for a long time over barren ground and then comes across a field of corn or other rich vegetation. My observations, though far from being complete, leave no doubt that a factor of utmost importance in the movement of larval swarms is temperature, and the following outline of the daily regime of a swarm will help to explain this.

It is a well-known fact that larval swarms do not move at all during the night, which they pass on plants in a semi-comatose state, caused doubtless by the low temperature. The first rays of the rising sun bring the larvae back to active life, and they begin at once to feed. The hotter the temperature grows, the more active become the insects, and soon they one by one jump or crawl down to the ground, where they continue to move about, now crawling, now jumping, as if feeling uneasy. Each larva in doing so disturbs its fellows, which leads to still more rapid general movement; this is at first entirely irregular, but sooner or later, through mutual influence, a common direction of movement is found and the swarm begins its day's march. So far as our observations in the Northern Caucasus go, the average temperature causing the first movements of the larvae lies near 13–15° C. In ordinary circumstances, *i.e.*, provided the sun shines all day and no unusual changes of weather occur, swarms keep moving the whole day, and as a rule do not feed when they move.* In the afternoon, when the temperature begins to fall, the velocity of the movement decreases until, in the evening, the swarm stops; it is very interesting to note that this evening cessation of movement occurs when the temperature is again near 13–15° C. One by one the larvae crawl up plants and begin to take their evening meal. There is no doubt that swarms do not choose their resting places, but simply stop where they are overtaken by the critical temperature. I have seen many swarms which have stopped for the night at entirely barren spots just after they have crossed a strip with abundant vegetation, or only a few yards before reaching it.

Such is the behaviour of larval swarms of *migratoria* under ordinary conditions of weather, and all my observations lead me to the definite conclusion that their movement has nothing to do with hunger and depends entirely on thermotropism (probably negative), and on another, as yet little known, tropism which is displayed by the tendency of each larva to repeat the movements of its nearest fellows and to move in the same direction as they do.†

The behaviour of larval swarms under abnormal conditions of weather lends further support to this conclusion. If the day is colder than usual and the temperature does not rise above 15° C., the swarm remains and feeds all day where it spent the night. If the temperature falls during a normally hot day, the swarm stops long before its usual time. Especially interesting and instructive is the following example: if a swarm is moving at the temperature in sunshine not much above the critical point and the sun is temporarily hidden behind a cloud, so that the temperature falls below that point, the swarm stops, or in any case its movement

* I intentionally avoid discussing here the question of the direction of movements and its causes, since it is very complicated, and besides, it has no direct connection with the chief problem we are now investigating; one point, however, is worth mentioning: that the direction of movement has, as a rule, nothing to do with the looking for food, since, for one thing, larvae do not feed during the day, and they often move from fertile spots into entirely barren places.

† This kind of tropism is not uncommon among other insects, and even vertebrates; a herd of cattle will afford excellent examples of it.

becomes slower and less defined ; as soon as the cloud has passed and the sun shines again, the swarms starts its march afresh ; even small clouds hiding the sun just for a few minutes produce the same effect.

There is likewise an upper limit of temperature that causes the cessation of movement ; and on very hot, close days swarms often stop their march during midday ; in that case, however, the larvae do not climb plants to feed but collect in close clusters under the plants, evidently hiding from the direct rays of the sun. This being a more rare phenomenon, I have no precise data as to the exact temperature at which it occurs, but anyhow it gives additional support to my theory that the movements of larval swarms depend primarily on thermotropism.*

After the final moult the wanderings of swarms on foot naturally cease, though when the majority of a swarm is in the last larval stage and only single individuals become winged, the latter may often be seen crawling and jumping with the swarm.

A few days after the last moult, newly-winged insects are incapable of long flight, their elytra and wings being not yet hard enough. This period is passed by swarms in the same spot, devouring vast quantities of food, and it is a very favourable (and also the last) opportunity for their destruction by spraying.

When locusts are fit for flight, single individuals begin to take wing and fly for a short distance, often circling above the still sitting swarm. Whenever a locust flies near enough to another that is at rest, the latter is disturbed and often takes wing and flies in the same direction ; this is again a manifestation of the same tropism which causes the movement of larval swarms. The larger the number of individuals with fully developed wings, the more often do they take these short flights, and the more other locusts join them, disturbing yet others when circling above the swarm. It is easy to understand that this must necessarily result, sooner or later, in the whole swarm taking wing. During the first movements no definite direction of flight is apparent, but since each individual tries to follow its nearest fellow, a common direction of flight must necessarily result. During the first few days these flights are rather irregular, and swarms do not assume a definite direction, but simply circle above their breeding grounds. If two swarms meet, they mix together, and so the swarm gradually grows larger and larger. The larger the swarms grow, the more regular and the longer become their flights, and at last the time comes when they assume a definite direction, and the insects take leave of their breeding region altogether ; then only few scattered swarms remain where just a day or two before locusts were numberless. In fact this emigration from the breeding regions is often so complete that only single individuals are left behind, and those prove to be nearly all parasitised by the larvae of Sarcophagid flies, or by red mites (*Trombidium*).

What is the cause of this emigration ? The generally accepted theory is that locusts migrate from want of food. I have already proved that this is not the case in the larval swarms, and as for flyers, the very idea of locusts being compelled to emigrate from breeding regions by the lack of food could never occur to anyone who has seen these vasts areas overgrown with luxurious vegetation of a kind most acceptable to locusts. In fact, swarms always leave behind them immense feeding grounds and emigrate sometimes to almost vegetationless deserts, which, as a rule, adjoin the permanent breeding areas of *migratoria*.

* The habits of the larval swarms of *migratoria* are well known to those concerned with locust control in Russia, and as the insects are now almost exclusively destroyed by spraying with arsenical insecticides, which are of use only when the actual food of the larvae is poisoned before feeding, no spraying is done during day, when swarms are in movement. The daily work is usually divided into two periods, and spraying is done in the early morning, before the larvae begin to go down from the plants, and in the evening ; the evening work begins before the swarms stop for the night, since it is always easy to reckon where a certain swarm will stop, and the spraying is continued till it is quite dark ; this evening spraying is the more effective. In cool weather, when swarms do not move, work goes on all day continuously.

Still more unacceptable becomes the theory of emigration being caused by lack of food, if we turn our attention to certain physiological changes which locusts undergo during the period of emigratiön. When dissecting individuals taken from emigrating swarms, it will be found that by far the greater portion of the inner cavity of the body is occupied by air-sacs, described long ago by American entomologists in the Rocky Mountain locust, and occurring doubtless in all other migrating species of locusts. These air-sacs are only temporary organs, reaching their highest development at the period of emigration and disappearing towards the end of that period, when the developing reproductive organs take their place. During the emigration, however, the air-sacs are enormously large and all the other internal organs are much compressed, including the stomach, thus rendering the insect almost incapable of taking food, at any rate in large quantities. This assumption, based upon anatomical facts, is supported also by field observations; for, in fact, the emigrating swarms, when they stop their flight, do not feed much, though incidentally they may cause great damage by merely cutting the stems of cultivated plants.

Further anatomical researches reveal also the fact that the fat-body is more developed in insects just before and at the beginning of emigration, and is almost exhausted towards the end of it ; probably locusts during this period live essentially on the food reserves in the fat-body, being unable to take much vegetable nourishment and consequently scarcity or even lack of food has nothing to do with the emigration.

A Russian entomologist, K. N. Rossikov, called attention to another possible explanation of the emigration of *migratoria* from its breeding grounds. He believed it to be an immediate result of the activity of the parasites of the adult locusts, *i.e.*, Sarcophagid larvae and red mites ; he believed that the parasitised individuals become restless and try to get rid of their parasites by flight. If this were so, the result would be that only parasitised individuals would emigrate and all the non-parasitised would remain behind in the breeding grounds, though actually just the opposite is observed. This theory, therefore, is as groundless as the previous one.

One more theory is that emigration might be regarded as a tendency of the species to avoid overpopulation of a breeding region and to find new suitable breeding grounds. As for the possibility of overpopulation of breeding regions of *migratoria*, this idea is simply absurd, since these regions are vast enough to harbour many hundred times more locust swarms than there are in years of maximal development.

To investigate the presumption that swarms are emigrating to look for new breeding grounds we must see what is the fate of swarms after they have left their permanent breeding regions.

As far as is known at present, a swarm of emigrating locusts usually covers a very long distance at one flight ; if sometimes it settles down on its way (and this is often caused by unfavourable conditions of weather), it soon resumes its flight again. I will not discuss here the question of the direction of the flight and its probable causes, since but very little is known about it. One fact, however, is firmly established and is of great importance for our immediate purpose : it is that in the majority of cases the swarms maintain throughout the same more or less defined direction which they assumed when starting ; of course, a strong wind or other incidental circumstances may to a certain extent alter this direction.

This straight flight, aimless and causeless as it seems, does not last long, though a swarm may cover during it very long distances, the velocity of flight being far greater than might be expected.

Sooner or later, the regularity of the flight seems to be lost ; swarms begin now to settle down, then take wing again and circle about ; they begin also to eat more, since their air-sacs have grown smaller and the fat-body is also exhausted. I believe,

therefore, that the cessation of flight is caused entirely by these two purely physiological phenomena, and it is obvious that no possibility exists for swarms to look for suitable new breeding grounds; they merely settle down wherever they are compelled to do so by their physiological condition, quite irrespective of the character of the locality. This may occur accidentally near some suitable spot, and there is also the probability that the swarm would find one during the irregular circular flights which take place at the end of the emigration and precede pairing and oviposition; but the extent of these flights is rather limited and this probability is correspondingly small. Theoretically it is far more probable that the cessation of emigration would become necessary in a locality quite unlike the normal breeding grounds.

A typical and very convincing example of this kind was observed in Stavropol province in the autumn of 1912, when numerous large swarms of *migratoria* emigrating from the breeding area at the mouth of the river Terek invaded that province. One or two of these swarms settled down in the lower portion of the valley of the river Kuma, which is itself a breeding region of the same locust, but was in that particular year free from the local swarms; the Terek swarms consequently found there most favourable conditions and oviposition took place in the normal manner. Practically all the other invading swarms stopped their flight in the steppe adjoining the middle course of the Kuma, some of them on the very border of the valley. Now this part of the valley presents some very suitable breeding grounds, which have often played an important part as the source of invasions in Stavropol province. Several of the swarms visited these grounds more than once during their circular flights, which are often supposed to serve the purpose of finding suitable places for oviposition. Ultimately, however, only a small number of scattered locusts oviposited there, while all the swarms deposited their egg-masses in the dry steppe, where the conditions of soil and vegetation are entirely different from those in normal breeding grounds. It is especially interesting to note that some of the eggs were laid on a portion of the steppe sloping towards the valley of the river, *i.e.*, in the closest proximity to the above-mentioned suitable area.

This latter fact and a study of the general conditions under which oviposition took place clearly show that nothing in the least like a conscious (or instinctive—the exact word does not matter in this case) choice of suitable places by swarms can be assumed. There is, however, one exception: when a swarm settles down for oviposition, and the females, after several attempts to penetrate the soil, find it too hard, they become restless, take wing again, and after a few rounds settle down at another spot. Thus we must conclude that oviposition takes place whenever the majority of females are ready for it, and quite irrespective of the suitability of the conditions for the next generation, provided that oviposition is physically possible.

In conclusion, the theory that emigration has as its aim the finding of new breeding places is also groundless, and there is at present no possibility of explaining the emigration by any causes except physiological ones: the development of the air-sacs compels the insects to fly, and this impulse is strengthened by their gregariousness, that is by some kind of tropism which makes each individual keep close to its fellows and follow their movements. Later on we shall see what is the biological meaning of the emigration.

Such is, briefly, the life-cycle of *migratoria*. The biology of the larvae and adults of *danica* is only very insufficiently known,* but what is known shows that their behaviour is entirely different from that of *migratoria*. The chief biological feature of the latter in both larval and adult stages—gregariousness—is quite absent in *danica*. This is especially striking in the larvae; if a wandering swarm of *migratoria*

* This is directly due to the fact that most entomologists have regarded *danica* as distinct from *migratoria* and as being an entirely harmless species, so that the study of its habits has been neglected.

larvae comes across a solitary specimen of the same form, the latter immediately joins the movement, but when a larva of *danica* is overtaken by a swarm of *migratoria*, it tries to escape by leaps as quickly as it can. At the same time, the larvae of *danica* seem to possess thermotropism of the same kind as that exhibited by *migratoria*, their time of feeding being restricted to the evening and early morning, while during the day they are probably also on the move, though I have no reliable observations on this point. As for the adults of *danica*, the only point of their biology that we know for certain is that they do not form swarms and hardly migrate at all; a study of their behaviour, as well as of their anatomy (air-sacs) is of the greatest importance for the solution of the whole problem.

Some very interesting indications of further biological differences between *danica* and *migratoria* have been obtained at the Turkestan Entomological Station by V. Plotnikov in his breeding experiments.* This entomologist obtained from typical individuals of *danica*, kept in the laboratory, a second generation of larvae in only 16–30 days after oviposition, instead of in the following spring as is usually the case with *migratoria*. In one particular experiment even three generations were bred in one year. That this unusually short period of hatching was not due to the unnatural conditions of the experiment is shown by the fact that eggs laid in the same laboratory by individuals of *migratoria* did not hatch before the following spring. Dissections of eggs showed that the development of the embryo begins in eggs of both *migratoria* and *danica* shortly after oviposition; but in the case of *migratoria*, when the embryo reaches a rather advanced stage, development is suspended for several months, corresponding to the period of hibernation, though in the laboratory there is no change in the conditions to account for this. At the same time and under exactly the same conditions, the embryos in eggs of *danica* develop without any interruption. These experiments suggest an explanation of the fact that, while the larval stages of *migratoria* may be found only in spring and the beginning of summer and the adults during the summer and autumn, there is no such strict regularity about the occurrence of the stages in *danica*, though many eggs of this form probably hibernate as well.

Field Observations on the Transformation of *migratoria* into *danica*.

During the great invasion of locust swarms which occurred in the Stavropol province in the autumn of 1912 (see p. 147), I used the opportunity for studying, from the systematist's standpoint, as large a series of specimens as possible. All the insects collected, which were taken from the swarms without any selection and amounted to many hundreds, proved to be quite typical *migratoria*. Nothing in the least like *danica* was observed in field, either by myself or by my assistants, whom I had previously instructed to look out for all aberrant forms and who knew *danica* perfectly well; the number of individuals thus studied without collecting them is difficult to estimate, but it doubtless amounted to many thousands. I believe, therefore, that I am right in assuming that the swarms consisted purely of *migratoria*, and that *danica*, or even intermediate forms, were entirely absent. The measurements of the specimens from those swarms are given in the fifth line of Table I (p. 139), and the following conclusions may be drawn from them: the specimens are rather uniform, the extent of their variability (0·16) being less than the average for *migratoria* (0·18—see line 1); the average figures for the pronotal (0·79) and the femoral (0·45) proportions are extremely near to the average for *migratoria* (0·80 and 0·46, respectively). The colour characters, though not very reliable, were very constant, which is not the case in *danica*. If we consider also that the locusts kept in close swarms which had no tendency to disperse, we must conclude that the swarms were formed exclusively by typical individuals of *migratoria*.

* Report on the work of the Turkestan Entomological Station in 1912, 1913, 1914, and part of 1915; pp. 28, 55–59; Tashkent, 1915 (in Russian); see also Rev. Appl. Entom., iv, p. 211.

According to the routine of the control work adopted in Russia, all the swarms were closely watched during their wanderings by the trained staff, and all the spots where oviposition took place were marked out and also noted on the maps. Owing to this procedure there was no doubt that in the following spring we had to conduct the destruction work against the immediate progeny of those swarms. As soon as the larvae in 1913 reached their third stage, when differences between *migratoria* and *danica* are more apparent than in the earlier stages, it became evident that although the bulk of the larval swarms consisted of *migratoria*, there were many individuals which were certainly *danica*, these being different in coloration and showing a tendency to desert the swarms. In spite of the intensive control measures, several small swarms escaped destruction and attained their final moult; these adult specimens proved to be rather different from those of their parental swarms (see line 6 of the table, p. 139). A rather large admixture of typical *danica* was very obvious, but still more numerous were specimens of an intermediate character which could not be identified either with *danica* or with *migratoria*; the bulk of the insects, however, might have been referred to *migratoria*, but showed an obvious inclination towards *danica*, in fact they had the pronotum more compressed laterally, the median keel more raised, the elytra longer and the femora relatively shorter, than in the specimens from the parental swarms; their coloration was also more variable. The proportions are especially instructive when compared with those for the swarms of 1912; in studying these figures one may see that the extent of variation was far larger than in 1912, and the average figures also changed in the direction of *danica*. The swarms were not so dense as in 1912, and the individual insects showed obviously less developed gregarious habits; numerous single individuals of *danica* were scattered all over the steppe, without any connection with the swarms; the latter did not undertake any migrations and gradually dispersed.

Similar, though less striking examples are given in lines 7 and 8, 9 and 10 of the table, in compiling which precautions were also taken to obtain the series most likely to represent two successive generations. Unfortunately, I could not secure reliable examples of more than two such generations from one spot.

Breeding Experiments by V. Plotnikov.

Though field observations like those described above are of great value, they have the disadvantage of not affording absolute proof, and the only way to obtain this is by breeding experiments. Such experiments have been undertaken by my friend V. Plotnikov, in Tashkent, and, though conducted on a very moderate scale, have yielded some most interesting and valuable results. Since all the actual specimens from these experiments were given to me by V. Plotnikov, and are before me now, I am able to give a little more detailed account of the results than were recorded in his original communication.

In the summer of 1913 several specimens of both sexes of very typical *danica* were isolated in cages, in which copulation and oviposition took place; the eggs hatched without hibernation, as is not uncommon with *danica*, but so far as we know never occurs in *migratoria*. The description of the larvae and adults bred from them is given by V. Plotnikov, as follows:—

"The larvae had in the first stage a dark grey coloration, and not black as in *migratoria*. In later stages they acquired various colorations—uniformly green, dark grey or brownish—but a number of them had the typical colouring of *migratoria*, namely, a general reddish brown colour (sometimes greenish), with velvety black stripes (broad or narrow) along the sides of the pronotal keel and black stripes on the sides of the abdomen. The adults presented no characters typical of *danica*; the profile of the pronotal keel was usually straight, sometimes even concave. The males were, however, smaller than the females."

After studying the specimens, I can only confirm Plotnikov's statement that while the parents are all very typical *danica*, save that not all of them have the hind tibiae red (which character is not quite constant in that form), their direct offspring are on the contrary all well-defined *migratoria*, though a few of them have the tibiae red, as is sometimes the case in this form. One of the parents and one of the off-spring are figured above (fig. 1, A, B, C, & D).

Another experiment is described by V. Plotnikov, as follows :—

" In 1914 I bred from egg-masses sent from Amu-Darya district* *P. migratorius*, and from egg-masses deposited by these insects I bred in the spring of 1915 again *migratorius*. On the 19th June I found in the soil of the breeding cage, where these individuals (now mature) used to live, five egg-masses, which I transplanted carefully into the soil of another cage ; there, on the 6th August, *i.e.*, more than 48 days after the oviposition, a single larva hatched, a female of dark grey coloration ; the rest of eggs in the egg-masses remained with an half-developed (hibernating) embryo. When in its second stage, this larva acquired a green coloration, which it retained till the fifth (final) stage. The profile of its pronotal keel was convex. . . . The adult insect retained the convex keel of the pronotum ; its body was green, the elytra light brown, and its hind tibiae turned red."

This specimen is before me now, and I can only confirm V. Plotnikov's opinion that it represents the most typical *danica*. As for its actual parents they possess all the essential characters of *migratoria* very well defined, and no one could hesitate to identify them with that form. Unfortunately the experiments were discontinued upon Plotnikov's joining the army.

V. Plotnikov's conclusion from his experiments is as follows: " . . . it is impossible to separate *P. migratorius* and *P. danicus* by any characters ; characters of *danicus* (including its capacity to produce a second generation) are expressed in the latter species more strongly. It is possible to suppose that this species is now in the process of splitting off from the primitive species, *P. migratorius*."

My own conclusions differ somewhat from this, but I shall come to them later on. All that I shall point out now is that these experiments prove finally the possibility of the actual breeding of *migratoria* from *danica* and *vice versa* ; my field observations on the same subject give evidence that it may occur not under laboratory conditions only, but in nature as well. On the other hand, we must not forget the numerous differences between them, especially the biological ones, which prevent us from regarding *danica* as a mere synonym of *migratoria*. It is evident that they must be regarded as two different forms of the same species without, in the meantime, any more precise definition of their systematic value.

Locusta migratorioides, Rch. & Frm.

This insect was described from specimens from Abyssinia ; later on, Saussure and other authors recorded it from many tropical localities. In its morphological features it is very much like *migratoria*, while its difference from *danica* is far more marked than in the latter. From *migratoria* it differs only in the following characters :—The pronotum (fig. 4) is still more constricted before the middle ; its median keel very low, often concave in profile ; fore margin almost straight ; hind margin very widely rounded ; the shoulder width almost equal to the length of the pronotum, the average pronotal proportion being 0·86, while it is 0·80 in *migratoria* ; the elytra relatively longer and the hind femora shorter, which results in the femoral proportion being on the average 0·44, as against 0·46 in *migratoria* (see Table I, lines 20 & 21).

* A permanent breeding region of *L. migratoria*.—B.U.

It is quite obvious from this definition that *migratorioides* presents no new features as compared with *migratoria*, but it seems to be in all the chief characters merely a further modification of *migratoria* in the direction opposite to *danica*. Unfortunately the material of *migratorioides* now at my disposal is rather scanty, and the extent of its variability remains uncertain. Still, there is in the British Museum one female taken at Sarkwalla, Northern Territories, Gold Coast, 4–7.xi.1915 (*Dr. J. J. Simpson*), which is in all respects intermediate between *migratoria* and *migratorioides*.

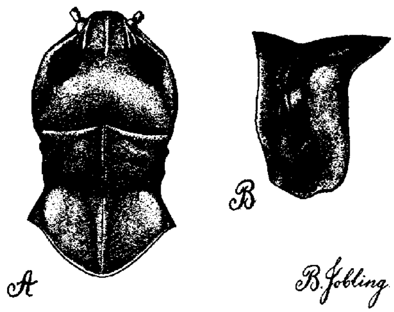


Fig. 4. *Locusta migratoria*, ph. *migratorioides*, Rch. & Frm., ♂ from Lagos: A, head and pronotum from above; B, pronotum, side view (× 3).

The study of the male genitalia of *migratorioides* reveals no difference whatever from the structure observed in *danica* and *migratoria* (fig. 7).

As for the coloration of the larval stages, we have a good description of them given by H. C. Pratt (*l.c.*) and from it, as well as from the study of the actual specimens sent by Mr. Pratt to me in 1913, I was unable to find any reliable difference between them and the larvae of *migratoria*.

On the other hand, Mr. Pratt says in his paper that the coloration of the larvae is not very constant and the green individuals occur alongside with the typically coloured ones. The figures of the green and black adults given in his paper (*l.c.*, pl. XIV) certainly represent *danica*. This is, then, an indication that the same interrelation exists between *migratorioides* and *danica* as has been proved positively for *migratoria* and *danica*. A confirmation of the same fact I received not long ago, when several specimens of locusts were sent from North Borneo to the Imperial Bureau of Entomology for identification. They all proved to be *migratorioides*, but as the lot was rather small, the Bureau asked for more material, and after several months a new collection arrived, with a note that the specimens were taken singly at the same spot as the swarms from which the first lot had been collected, and represented the actual offspring of those swarms. All specimens in this second lot are quite typical *danica*.

One more example of the transformation of *migratorioides* into *danica* I have found in Dr. La Baume's paper on the African locusts.* In a reference to Dr. L. Sander's book† he discusses an invasion of locusts which took place at Misahöhe, Togo, in December 1893, while in March 1894 new larval swarms appeared at the same locality, which Dr. Sander believed to be the direct progeny of the December swarms.

* Die Afrikanischen Wanderheuschrecken.—Beih. zum Tropenpflanzer, xi, No. 2, 1910, p. 82, footnote 22.

† Die Wanderheuschrecken und ihre Bekämpfung in unseren Afrikanischen Kolonien. Berlin, 1902.

These latter consisted, as Dr. La Baume stated after a study of the specimens, of *migratorioides*, while the March swarms, again according to his determination, were composed of *danica*, which leads him to the conclusion that they could not possibly be the direct progeny of the December swarms. I believe, however, that Dr. Sander (who simply did not distinguish *migratorioides* from *danica*) was right, and that the December swarms of *migratorioides* actually produced the March swarms of *danica*.

All these facts, of course, do not furnish us with absolute proof of the transformation of *migratorioides* into *danica* ; but since such a transformation is firmly established for *migratoria* and *danica*, I feel justified in assuming it to be true in this case also.

Geographical Distribution.

Of the three forms here dealt with, *danica* has the most extensive range ; in fact, it is found throughout the whole of the Eastern hemisphere, except the coldest regions beyond 60° northern and southern latitude, very high mountains* and vast waterless deserts. As for the Western hemisphere, though many books state that *danica* occurs in America, I know of no reliable evidence to this effect, and am fully convinced that all the older records are due to mistakes, either in labelling the specimens or in their identification.** Thus, F. Walker described *Pachytylus brasiliensis*, which is conspecific with *danica*, from a specimen in an unlabelled collection which included insects not from Brazil only, but from other parts of the world also, and the mistake in locality in this case is beyond doubt.

A form with such an enormous area of distribution may be expected to present some geographical variations, and in fact, apart from the individual variability which, as I have already stated, is very great in *danica*, some more constant variations, probably connected with geographical conditions, are also observed. Thus Australian and New Zealand specimens are rather small on the average, with a comparatively short pronotum and the wings slightly infumate ; they have been described by Saussure as a distinct species, *Pachytylus australis*, Sauss. As, however, no one has yet studied extensive series of individuals of Australian origin, the constancy of these characters is not proved; on the other hand, specimens of the same kind occur incidentally in other localities as well, and their distinctions from the typical *danica* do not exceed the average extent of observed individual variability. Again, as I have already pointed out (p. 139), there is a slight difference between the individuals of *danica* from the Palaearctic region and those of tropical origin, which also may depend on geographical conditions ; but in this case likewise more extensive investigations are wanted.

The area of distribution of *migratorioides*, though not so extensive as that of *danica*, still occupies the greater part of the latter, in fact the whole of it except the Palaearctic region.

The latter region is the home of *migratoria*, which is however common in its south-eastern parts only (especially in the basin of the Black, Caspian and Aral Seas and that of Lake Balkhash), where its permanent breeding grounds are, while its emigrating swarms penetrate much farther north and westwards, sometimes as far as Finland and England. On the other hand, single individuals, which agree in all their morphological characters with *migratoria*, occur far beyond the Palaearctic region as well. Thus, Brunner v. Wattenwyl recorded† *migratoria* from the Malay Archipelago (Batjan and Borneo). I have myself seen a quite typical specimen of

* I have recorded (Revue Russe d'Entom., xiv, 1914, p. 232) this form from the Pamir upland as high up as 11,000 ft. above sea-level ; there is in the British Museum a couple of specimens taken at Giangtse, Tibet, at an altitude of 13,000 ft.

** Dr. J. Rehn, of Philadelphia, informed me recently that he is of the same opinion.

† Abh. Senkenberg. Naturf. Ges., xxiv, pp. 194, 196.

migratoria sent from Southern Celebes by Dr. Roepke to the Imperial Bureau of Entomology, which had the following note attached: "A Locustid from S. Celebes (Pangka djene) appearing there in small swarms and causing damage to the natives' plantations, such as rice, corn, etc."

The Theory of Phases.

Though the above recorded facts by no means exhaust the points to be considered in connection with the problem of the interrelations of *migratoria, danica* and *migratorioides*, they yet permit us to make an attempt to find out the best explanation at present possible. The following theory seems to me to agree in a rather satisfactory manner with all the facts known at present, though some modifications of it may prove to be unavoidable when new data are available.

As a starting point, I take it as positively proved that the three forms cannot be separated specifically and that they represent taxonomic units of lower grade than the species, which must be called, according to the law of priority, *L. migratoria*, L. They are, however, quite distinct from each other, though connected by transitional forms.

What term, then, should be applied to them? They are certainly not mere individual aberrations—as they are often assumed to be by other authors—since they are rather constant in their average morphological characters and still more so in their biology; nor can we call them subspecies, *i.e.*, geographical races, as they are found together in the same locality; nor are they seasonal forms, since the transformation of one of them into the other has evidently nothing to do with season. The only more or less suitable term for them is "morpha," in the sense proposed by A. P. Semenov-Tjan-Shansky,* who proposed to apply this name to such forms of a species that present a direct result of the immediate external influences on the individual insect during its development, and which therefore do not appear in succeeding generations if the original influence ceases. Under this definition come seasonal forms, which may be obtained by the artificial application to developing individuals of certain factors causing their appearance under natural conditions; the forms resulting from feeding larvae by some special food, etc. The same term may be applied, according to the personal opinion of A. P. Semenov-Tian-Shansky, expressed in his letters to me, to the case of the *Locusta* forms. It seems to me, however, that the term "morpha" is rather vague, and moreover we are yet far from knowing whether the transformation of one form into the other is due to some immediate external influence or to some yet unknown internal cause; I think, therefore, that the term "phase" (Latin *phasa*; abbreviation—*ph.*) suggested to me by Dr. G. A. K. Marshall is more appropriate, and its meaning will be made clear in the course of the explanation of my theory.

There is no doubt in my mind that *migratorioides* is the oldest form of the species, since its morphological and colour characters are far more constant in comparison with the more plastic *migratoria*, to say nothing of the extremely variable *danica*. The permanent breeding regions of *migratorioides* have never yet been investigated; the only description of breeding places of this form in the Malay States given by H. C. Pratt (*l.c.*, pp. 6–7) must obviously be referred not to the permanent breeding grounds, but merely to the places where the oviposition of emigrated swarms took place. All we know at present concerning the permanent breeding areas of *migratorioides* is based on the records of the occurrence of its swarms; and these data enable us to state that the best conditions for the development of this form seem to be present in tropical countries with a rather damp and hot climate, but undoubtedly not in forests. Since, on the other hand, these breeding grounds seem to be yet undiscovered, we may presume that they are also not in open, grassy land,

* Die taxonomischen Grenzen der Art und ihrer Unterabteilungen. Berlin, 1910.

which is easily accessible and mostly cultivated or, anyhow, populated. I believe, therefore, that permanent breeding grounds of *migratorioides* are to be looked for somewhere deep in the impenetrable jungles, overgrown with high grasses, reeds, and such-like vegetation; but even if I am mistaken in this supposition, it would not affect my theory, which is based on the indubitable fact that the permanent breeding of *migratorioides* is possible only in localities with certain natural conditions, whatever those conditions may actually be.

Another well-known fact is that the development of *migratorioides* in its breeding grounds does not go on always at the same rate, but that it is subject to a periodical rise and fall, though the exact cause of the increase of locusts is entirely unknown. When the increase is at its height, large swarms are formed, and their emigration follows. Such emigrated swarms settle down and oviposit whenever they are compelled to do so by purely physiological causes, and their progeny undergoes a transformation into the solitary-living phase—*danica*. The very plastic, easily adaptable, and in all respects more progressive *danica* must play an important part in the extension of the range of the species, gradually but steadily populating new regions. Being a product of a mutation arising partly from some unknown internal cause and partly from outer (probably climatic) influences, *danica* is naturally subject to sudden displays of atavism, which results in the transformation into the ancestral phase *migratorioides*. We do not know yet whether this phenomenon can occur spontaneously as a result of some internal physiological factor, but there is no doubt that it is much favoured and often probably caused by the oviposition of *danica* taking place under conditions like those of the permanent breeding grounds of *migratorioides*. The gregariousness of the *migratorioides* phase is, of course, one of the causes of a rapid increase in the number of individuals and swarms, and soon—in the course of a few generations—the size of the swarms reaches the maximal point, which is followed by emigration. In this way the dispersion of the species goes on alternately by the gradual spreading of the *danica* phase and by the periodical extensive emigrations of *migratorioides*. As a result, the species is now distributed all over the Eastern hemisphere; but, as we know, the distribution of *migratorioides* is limited to tropical regions only, while *danica* goes over to the Palaearctic region as well, where the swarming phase of the species is represented by *migratoria*. This latter fact might be satisfactorily explained by the impossibility of finding in the Palaearctic region the natural conditions exactly like those of the tropical breeding grounds of *migratorioides*, chiefly in regard to a combination of heat and dampness. The above-described (p. 143) reed-beds of *Phragmites* in the south-eastern part of the Palaearctic region represent in all respects the nearest possible approach to tropical conditions. This statement is strongly supported by the fact that the fauna of these reed-beds includes two more Acridians of an undoubtedly tropical origin; these are *Gelastorrhinus sagitta*, Uvar., and *Oxya turanica*, Uvar., both described* from the valley of the Amu-Darya, in Transcaspia, and the former found also on the River Kura, in Transcaucasia. Though very peculiar, and in the summer recalling the tropics, the climatic conditions of these reed-beds are, of course, not tropical, and their effect on the progeny of *danica* breeding there is not the same as in the tropical breeding grounds of *migratorioides*: the reverse transformation of *danica* into a swarming phase does not reach the phase of *migratorioides*, but stops half-way at the *migratoria*-phase. This seeems to indicate that the transformation is due primarily to the direct influence of external conditions, its extent being proportional to changes in the latter, but only precise laboratory investigations can help to clear up this complicated problem. It is interesting to recall here that individuals of *migratoria* incidentally occur in tropical countries also (see p. 152), and we may presume that their appearance is due to some abnormal conditions of the development.

* Horae Soc. Entom. Ross, xl, No. 3, 1912.

Little is known yet as to what happens in the breeding grounds after the emigration,* except that the number of locusts drops suddenly to a minimum. I presume that scattered swarms of the gregarious phase, as well as the progeny of individuals of the solitary phase, cause the gradual increase in the number of swarming individuals, and after a few years a new emigration occurs.

Thus, the periodicity of locust invasions is caused entirely by the wonderful phenomenon of the transformation of a swarming locust into a solitary, harmless grasshopper. Of course, the outline here sketched is necessarily rough, and the actual proceedings are far more complicated, but the theory seems to me to be the best possible in the circumstances.

The biological result of these phenomena is that the maintenance and dispersion of the species is ensured in all circumstances: the swarming phases enable the species to extend at one stroke its area of distribution to distant regions, and its dispersion to the remotest islands is undoubtedly due to emigrating swarms; on the other hand, the well protected and easily adaptable solitary phase secures a strong footing in the countries thus reached, and under favourable conditions gives rise to new emigrants; the results achieved show that such an arrangement has been extremely useful to the species. Even the most radical changes in the natural conditions of the permanent breeding regions would result not in the extermination of the species, but only in its transformation into the more adaptable *danica* phase.

An example of that kind occurred in Southern Russia. Though the now existing permanent breeding regions are restricted, as I have described above (p. 143), to the valleys of the rivers discharging into the Caspian and Aral Seas and Lake Balkhash, the deltas of rivers emptying into the Black Sea (*i.e.*, Kuban, Don, Dnieper, Danube, etc.) also harboured not very long ago—up to the end of the eighties of the last century—some permanent breeding grounds of *migratoria*. At present, however, only the lower valley of the Danube is still a breeding region, while the valleys of the other rivers of the basin of the Black Sea no longer serve that purpose. This is easily explained by the fact that the valleys of the Don, Kuban and Dnieper were during the end of the last century more or less cultivated or, at any rate, their natural conditions were entirely changed by the persistent grazing of herds of cattle. As a direct result of this the possibility of the transformation of the solitary phase into the swarming one exists there no longer, and though the transformation takes place incidentally, single specimens of *migratoria* being not uncommon, their numbers do not increase, nor are swarms ever found.

The theory of phases suggests the theoretical possibility of the control of *migratoria* by some measures directed not against the insect itself, but against certain natural conditions existing in breeding regions which are the direct cause of the development of the swarming phase. The above-quoted example in South Russia shows that even comparatively slight cultivation of breeding regions leads to the desired changes; but the conditions necessary for the breeding of the swarming phase have not been exactly studied, nor are the direction and extent of such changes known. The first step, therefore, should be the most careful investigation of all existing, as well as extinct, breeding regions, together with parallel breeding experiments under laboratory conditions; on the basis of results thus gained a system of theoretically useful and practically possible measures for the conversion of breeding regions may be outlined.

IV. *Locustana pardalina*, Walk., and its Phases.

My personal knowledge of this locust is limited to the study of preserved specimens, especially of a large series sent to the Imperial Bureau of Entomology by Mr. J. C. Faure,

* The direct cause of this ignorance is that injurious insects, and locusts especially, are studied only in the years of maximum development, and nobody cares about them in the minimum years, when the clue to the whole locust problem is most likely to be found.

of the Division of Entomology, Pretoria. Before proceeding to my own observations on the morphology of the species, I will quote an extract from a letter from Mr. Faure, dated 14th October 1920, which includes some very important and interesting information on the question of the phases of *L. pardalina.*

"My personal experience with the species began in the summer of 1914-15, when scattered swarms began to appear shortly after the break-up of a prolonged and very severe drought. Voetgangers (*i.e.*, nymphs) of all stages and flyers occurred together in loose swarms, and it was practically impossible to destroy them by the usual method of poisoning. The swarms did not move in the usual compact formation, nor did they camp for the night in dense clusters. Many of the adults were strikingly undersized, and a large percentage of both adults and voetgangers were abnormally coloured. Only in swarms that approached the normal in density did the typical orange and black colour of the voetgangers begin to show up.

"Although I did not realize the fact at the time, I was witnessing the transition from the grasshopper to the swarm phase. Towards the winter, that is in May and June 1915, the flyers began to move about in fairly definite loose swarms, and they laid their eggs in compact deposits, with the result that large swarms of typical swarm voetgangers hatched the following spring. We received no reports that winter of swarms of flyers coming into the Union from the Kalahari or anywhere else, and the outbreak in the period September to December 1915 was very severe in the area in which the scattered locusts had been observed the previous summer.

"It was quite evident, therefore, that the invasion of September-December 1915 had arisen from locusts bred up within the borders of the Union. Formerly the Kalahari Desert had been thought to be the chief source of our invasions of *Locusta pardalina*. Now we are convinced that large outbreaks can and do arise within our borders without the help of swarms coming in from the Kalahari. In the past, huge swarms have undoubtedly come into the Union from the Kalahari, and no doubt history may repeat itself in the future. But we no longer regard the Kalahari as a sort of permanent breeding ground, and are now inclined to believe that it will ordinarily only develop into a breeding ground if we allow swarms of flyers to escape into it from the Union.

"In 1917 I again saw scattered locusts from February to April, and another severe outbreak of voetgangers occurred the following spring and summer. In a general way it was a repetition of what had occurred in 1915, and realizing what was going on, I was better able to make observations.

"*Locusta pardalina* does not merely occur in scattered swarms and in compact swarms—it also lives as a grasshopper, *i.e.*, single specimens have often been collected miles away from the nearest swarm and in seasons when no swarms have been known to exist anywhere in the country. I have good reasons for believing that the species is probably never entirely absent from certain parts of the Union. During the past five years I have often searched for specimens during the intervals between the occurrence of swarms, and in practically every case I have succeeded in capturing two or three at least in say an hour's walk on the veld. Of course one should not expect to find them late in the winter or during a bad drought.

"The specimens captured singly almost always have the colours of the grasshopper phase, and they are as a rule a good deal smaller than swarm forms. Further, I have frequently taken last-stage nymphs and newly-fledged adults living the life of single grasshoppers. Although I have not been able to make a careful study of the specific characters of these single living forms, I am quite satisfied in my own mind that they are identical with the swarm forms. Again, these single forms may occur in the district or on the farm on which swarms are present, and I have on several occasions seen a few individuals with abnormal colours amongst a swarm

of typical swarm-form voetgangers. The only conclusion I could come to was that these stray forms have been picked up by the swarm. I have also found grasshopper-phase adults in a swarm of swarm-phase flyers, and have seen a very small green-marked male in copulation with a large typical female.

"These single forms of *L. pardalina* can readily be distinguished in the field from our other veld grasshoppers (1) by the fact that they have milky-white glistening underwings, and (2) by their peculiar manner of flight. They almost always soar upwards and then dip and swerve before settling down.

"From the swarm-phase the grasshopper-phase of *L. pardalina* differs chiefly in size and in colour. As regards colour, the single forms are remarkable for their great variability, and it would be quite an undertaking to describe in detail all the shades of colour they exhibit. Usually there is a striking protective resemblance. Where there is plenty of green grass both voetgangers and flyers may be almost entirely green, or at least partly green. Where the veld is only sparsely covered with grass and bushes, they resemble the colour of the soil more or less. In parts of the Karroo, notably Beaufort West and Prince Albert, there are patches of gravelly soil varying from slaty-blue to almost black. In 1917 I was greatly surprised to find a very striking tendency amongst the scattered veotgangers to vary in colour from place to place more or less in accordance with the colour of the soil. When the progeny of these scattered locusts appeared on the same farms in swarms six months later there was no trace of such a protective resemblance; they all wore the King's regulation swarm uniform!

"As far as size goes, the single-living forms are generally considerably smaller than the swarm forms. This is especially true of the males. Some of the males are so small that one can scarcely believe that they belong to the same species as the swarm males.

"When it occurs in large swarms *L. pardalina* scatters far and wide over the central plateau of South Africa, but its natural home is in the semi-arid parts of the country. It does not like the eastern Orange Free State, for instance, where there is a fairly good rainfall and a rather dense growth of grass. Its favourable breeding grounds are districts like those in the south-western corner of the Free State where the rainfall is slight and the veld consists of short grass mixed with short Karroo bush (*Pentzia*). In looking for scattered brown locusts I have got the habit of going to spots in the veld where there is an outcrop of white limestone in the red sand."

These valuable observations of Mr. Faure's leave no doubt that *L. pardalina* has, like *L. migratoria*, two different phases, which differ in morphology and coloration, but more profoundly in the biology. Especially striking is it that there is a sort of parallelism in the variation from the swarming to the solitary phase in both these species, as will be presently evident. My study of extensive series of both phases of *pardalina* sent by Mr. Faure, with a careful designation of the conditions under which each particular lot was collected (*i.e.*, whether from swarms or singly), enables me to state the following differences between them.

The difference in the shape of the pronotum is well marked, though less striking than that between *migratoria* (or *migratorioides*) and *danica*. The pronotum of the swarming phase of *pardalina* (fig. 5, A & B) is more constricted before the middle, with the fore margin feebly prominent, the hind angle distinctly rounded, and the median keel slightly lower, and deeper cut by transverse sulci than in the solitary phase (fig. 5, D & E); but it is hardly possible to express these differences in figures, as I have done for the phases of *migratoria*, in which they are far more pronounced.

It is possible, however, to apply the method of proportions to another character—that of the relative lengths of the elytra and hind femora. As in *migratoria*, the elytra of the swarming phase of *pardalina* are relatively longer and the hind femora

shorter than in the solitary phase. The femoral proportion (*i.e.*, the length of hind femora expressed as a percentage of the length of the elytra) in the swarming phase averages 0·44, with a maximum of 0·47, and a minimum of 0·41; the average proportion for the solitary phase is 0·46, with 0·50 maximum and 0·41 minimum.

While the elytra of *migratoria* and *danica* do not differ except in the relative length, there exists a well-marked difference in the shape and venation of the elytra in the two phases of *pardalina*. Those of the swarming phase (fig. 5, C) are broader, with the fore margin more convex and the apex obliquely rounded, while the solitary phase (fig. 5, F) has the elytra narrower, with the margins almost straight and parallel and the apex obliquely truncate. The most striking difference, however, is in the venation: the discoidal field in the swarming phase is much broader, and its false vein distinctly curved and much thicker than in the solitary phase, in which this field is rather narrow, parallel-sided, and with the false vein only slightly thickened and almost, or even quite, straight. Naturally all these characters are subject to variation, and forms in all respects intermediate occur.

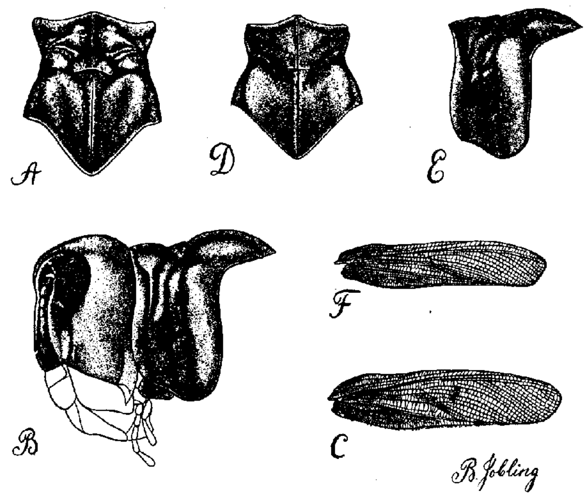


Fig. 5. *Locustana pardalina*, Walk.: A, B, C, phase *pardalina*; D, E, F, phase *solitaria*, Uvar., nov.; C and F, natural size, remainder × 3.

The difference in the absolute dimensions between the two phases of *pardalina*, noted by Mr. Faure, is a phenomenon not observed in *migratoria*, but in the South African species it is well marked, the average length of the body of the swarming phase being 41 mm., while in the solitary phase it is only 34 mm., and occasional specimens occur even as small as but 24 mm. The individual variability in size is in the solitary phase very extensive, but the swarming phase is rather constant in this respect; this is also the case in the phases of *migratoria*. Again, sexual dimorphism is as well marked in the solitary phase of *pardalina* as it is in *danica*, the average length of the body being 32 mm. in the males and 36 mm. in the females, while the difference in the size of dwarf males, attaining about 22–24 mm., and the largest females with a length of nearly 45 mm. is very striking. The males of the swarming phase are scarcely smaller than the females, which agrees with the relative size of the sexes in typical *migratoria* or *migratorioides*.

The extremely variable and decidedly protective general coloration of the solitary phase of *pardalina* in all stages of post-embryonic development, noted by Mr. Faure, exactly corresponds with the coloration of *danica*. The larvae of the swarming phase of *pardalina* present an astonishing likeness to those of *migratoria* and *migratorioides*, the coloration presenting the same combination of orange and black.* The adults of the swarming form are rather uniformly coloured, and some bright yellow specimens in the series sent from Pretoria lead me to the suggestion that at the time of mating a general change of coloration may occur, as it does in *migratoria* (see p. 143). In the coloration of the most aberrant individuals of the solitary phase, one particular feature is noteworthy: the presence of a more or less pronounced pale or white oblique cross on the pronotum, which design is very characteristic of the species of the closely related genus *Oedaleus*.

An examination of the male genitalia revealed no difference whatever between the two phases of *pardalina*, but this was only to be anticipated.

The above-quoted conclusions of Mr. J. C. Faure concerning the transformation of the solitary phase into the swarming one, at which he arrived quite independently of my work on *migratoria*, give a very strong support to the theory of phases as a direct cause of the periodicity. His observations are especially interesting because they concern the period of the transition from the solitary to the swarming phase, on which my investigations of *migratoria* have given very few facts. It seems that in

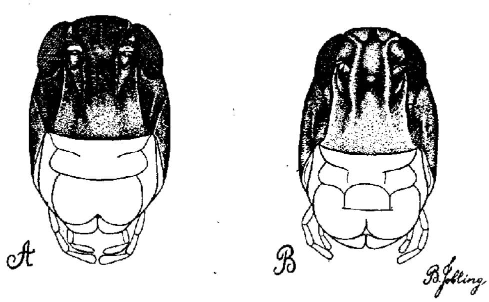


Fig. 6. Front view of head of: A, *Locusta migratoria* ph. *danica*, L.; B, *Locustana pardalina* ph. *pardalina*, Walk. (× 4).

pardalina the transformation of solitary individuals into the swarming phase takes more than one generation, but the actual causes of the transformation are in this case also obscure, as they are in *migratoria*. Data as to the migrations of the flyers and the fate of migrating swarms of *pardalina* are yet lacking, and further investigations of this problem, closely connected with the careful study of all conditions of breeding grounds, are extremely important from the point of view of locust control in South Africa.

V. Systematic Part.

Key to the Genera Locusta, *L.*, *and* Locustana, *g. n.*

1 (2) Frontal ridge not widened at the median ocellus (fig. 6, A). Pronotum (fig. 1, A, B, C, D, E) with the typical transverse furrow cutting the median keel about its middle; furrows in the prozona feeble. Mesosternal lobes only a

* It is extremely interesting to note here that the larvae of most swarming and migratory locusts (*Schistocerca peregrina*, Ol., *Dociostaurus maroccanus*, Thb., etc.) present the same general type of coloration in black and reddish, or yellow, forming a very striking design. This phenomenon is well worth further investigation.

little longer than broad. Elytra (fig. 1, F) not less than five to six times as long as their maximal width ; hind radial vein diverging from the middle radial only slightly and close to the bifurcation of the former ; discoidal area much shorter than half the elytra ; inter-ulnar area about half as broad again as the discoidal area, rather densely areolated, with areolets more than three deep, without a regular false vein. Hind femora narrow, more than four times as long as their maximal width ; their upper margin more or less distinctly serrate ; upper carina of the externo-median area straight. ♂ : supra-anal plate (fig. 7, A) triangular, its surface practically flat ; cerci (fig. 7, A) short, rounded, conical ; subgenital plate with apex obtusely conical ; penis (fig. 7, B) very large, strongly recurved apically. ♀ (fig. 7, E) : subgenital plate with lateral margins straight ; apex truncate ; lower valves of ovipositor with basal part distinctly longer than broad, with an obtuse lateral tooth in the apical part .. .. .. *Locusta*, L.
Genotype : *Gryllus Locusta migratoria*, L.

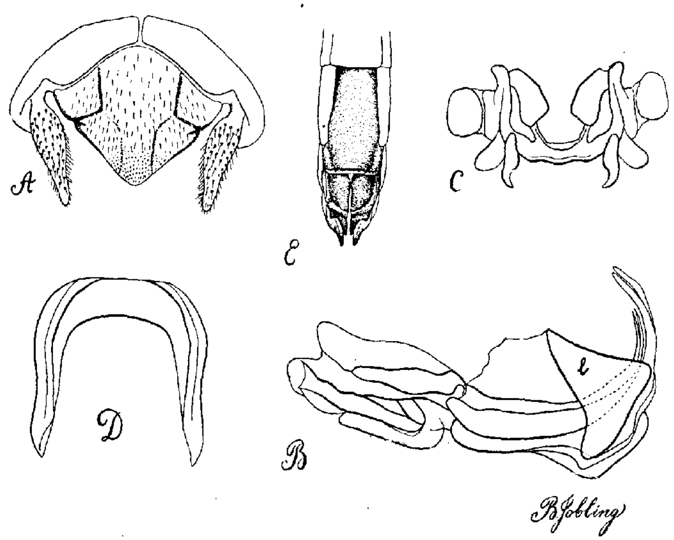


Fig. 7. Genitalia of *Locusta migratoria*, L. : A, male supra-anal plate and cerci from above ; B, penis and lower genital valves (*e*) in profile ; C, epiphallus ; D, upper bridge of genital valves ; E, end of female abdomen from beneath. (E × 3, remainder × 12).

2 (1) Frontal ridge distinctly widened at the median ocellus (fig. 6, B). Pronotum (fig. 5, A, B, D, E), with the typical transverse furrow cutting the median keel distinctly before the middle ; furrows in the prozona deep. Mesosternal lobes distinctly longer than broad. Elytra (fig. 5, C, F) not more than four to five times as long as broad ; hind radial vein strongly diverging from the middle radial long before its bifurcation ; discoidal area almost as long as half the elytra ; inter-ulnar area about as broad as the discoidal, sparsely areolated with two rows of areolets, separated by a false vein. Hind femora broad, less than four times as long as their maximal width ; their upper margin not serrate ; upper carina of the externo-median area convex. ♂ : supra-anal plate (fig. 8, A) trapezoidal, with the apex prominent in the middle, irregularly denticulate, its surface with chitinous tubercles ;

cerci (fig. 8, A) rather large, compressed laterally; subgenital plate with the apex slightly widened; penis (fig. 8, B) very short, with short acute apex. ♀ (fig. 8, E): subgenital plate with lateral margins slightly convex; apex rounded, with a median projection and bisinuate laterally; lower valves of ovipositor with the basal part about as long as broad, the apical part unarmed laterally .. .. *Locustana*, g. n.

Genotype: *Pachytylus pardalinus*, Walk.

This key shows only the most striking differences between the two genera; other distinctive characters, especially those observed in the male genitalia, may be easily understood by a comparison of the figures (figs. 7 and 8).

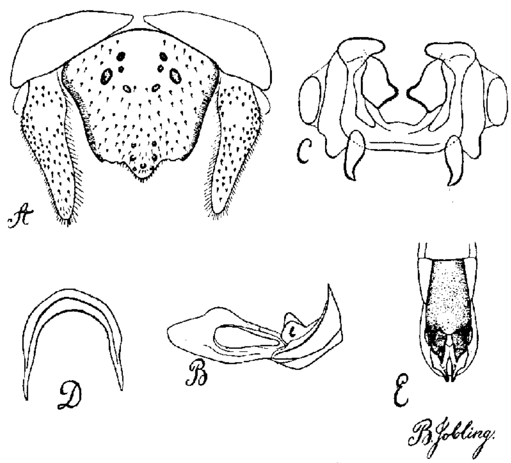


Fig. 8. Genitalia of *Locustana pardalina*, Walk.: A, male supra-anal plate and cerci from above; B, penis and lower genital valves (*e*) in profile; C, epiphallus; D, upper bridge of genital valves; E, end of female abdomen from beneath. (E × 3, remainder × 12).

A full description of the new genus *Locustana* is given below.

Key to the Phases of Locusta migratoria, *L.** (figs. 1 & 4).

1 (2) Pronotum distinctly compressed laterally, but feebly constricted before the middle; median keel high, tectiform, convex in profile; the fore margin angulately prominent; the hind angle acute. Hind femora (on the average) longer than half the elytra. Hind tibiae often red. Larvae of variable coloration, but never black and red (or black and yellow). Both larvae and adults occur singly or in very loose swarms .. .. ph. *danica*, L.

2 (1) Pronotum only feebly compressed laterally, but distinctly constricted before the middle; median keel low, neither tectiform, nor convex in profile; fore margin not prominent; hind angle not acute. Hind femora (on the average) shorter than half the elytra. Hind tibiae only exceptionally red. Larvae of a constant black and red (or black and yellow) coloration. Both larvae and adults occur in dense swarms.

* It is quite obvious that the exact determination of the phases is possible only in the case of typical specimens and not of intermediate examples; the most reliable results can be obtained only from examination of large series.

3 (4) Pronotum with the median keel straight in profile; hind margin rotundato-angulate .. .. ph. *migratoria*, L.

4 (3) Pronotum with the median keel concave in profile; hind margin widely rounded .. .. ph. *migratorioides*, Rch. & Frm.

Synonymic Notes.

The synonymy of *L. migratoria* ph. *migratoria*, L., and *L. migratoria* ph. *danica*, L., is quite correctly given by W. F. Kirby in his Catalogue (iii, pp. 229, 230), apart from the fact that he distinguishes them as two different species, and I think it unnecessary to repeat it here. To the synonyms of *danica*, however, must be added *Pachytylus australis*, Sauss. (Prodr. Oedip., pp. 119, 120, no. 5, 1884), but not *Locusta australis*, Froggatt (Agric. Gaz., N.S. Wales, xiv, p. 110, 1903), which represents *Gastrimargus musicus*, F., as has already been stated by Prof. Y. Sjöstedt (Ark. Zool., xii, no. 20, p. 11, 1920).

Pachytylus capito, Sauss. (Prodr. Oedip., pp. 119, 120, no. 4, 1884) is undoubtedly identical with *L. migratoria* ph. *migratorioides* (Rch. & Frm.).

Pachytylus minor, Sauss. (Abh. Senck. Naturf. Ges., xxi, p. 631, 1899) belongs to the genus *Pternoscirta*, as I am able to state from an examination of good photographs of the type specimen most obligingly taken for me by Dr. J. Carl, of the Geneva Museum.

The only remaining species of *Locusta* in Kirby's Catalogue is *L. pardalina* Walk., conspecific with *sulcicollis*, Stål, and *capensis*, Sauss., which is here made the type of the new genus *Locustana*, m.

A Description of the Genus *Locustana*, **nov.** (figs. 5, 6 B & 8).

Antennae distinctly compressed dorso-ventrally. Frontal ridge in profile straight or feebly concave, distinctly widened and impressed around the median ocellus, flat elsewhere, with the margins very obtuse, disappearing just below the ocellus. Fastigium of the vertex slightly sloping, forming a straight widely rounded angle with the frontal ridge, flat, distinctly longer than broad, with the margins distinctly raised, convex, with the median keel always developed; the distance between the eyes slightly less than twice as broad as the frontal ridge between the bases of the antennae. Eyes oval, with the fore margin almost straight; their width in the broadest part, which is in the middle, is equal to about half their maximal height. Pronotum with the prozona constricted, deeply furrowed, convex between the furrows; the typical furrow cuts the median keel distinctly behind the middle; median keel moderately elevated; lateral lobes with the hind angle widely rounded. Mesosternal lobes distinctly broader than long, their inner angles widely rounded; mesosternal interspace subquadrate in the female and slightly longer than broad in the male. Elytra hyaline throughout, except the basal parts of the marginal and basal areas, which are coriaceous; rather broad and short, not more than four to five times as long as their maximal width; apex oblique; hind radial vein strongly diverging from the middle radial long before its bifurcation (halfway between the base and the bifurcation); discoidal area almost as long as half the elytra, with a sinuate or straight false vein; inter-ulnar area about as broad as the discoidal, or scarcely broader, sparsely areolated, with two rows of the areolets separated by a rather regular false vein; axillar vein free, in most cases reaching the hind margin. Wings rather short, not more than twice as long as their greatest width. Hind femora rather broad—less than four times as long as their maximal width; upper keel not serrate; upper carina of the externo-median area distinctly convex.

♂.—Supra-anal plate, with strongly chitinized margins, trapezoidal, distinctly longer than the basal width; its surface distinctly concave, with several small chitinous tubercles in the basal half, forming a trapezium; outer margins nearly straight;

apex triangularly prominent, irregularly denticulate; hind angles obtusely rounded. Cerci rather large, strongly compressed laterally. Subgenital plate subconical, with the apex attenuate and slightly widened. Penis* short, widely and obliquely truncate posteriorly, with the apex triangular, sharp; upper genital valves large, united with the penis; lower valves small, lying close to the sides of the penis and covering about half of it laterally, with obtuse upper projections; they are connected with each other above the penis by a bow-shaped transverse bridge emitting forwards two long, apically narrowed, lateral branches; epiphallus large, with the two upper apophyses obtusely rounded and projecting inwardly and with lower sharply pointed, beak-shaped teeth, with the inner lobes rounded and minutely and obtusely serrate near the lower angles.

♀.—Supra-anal plate obtusely triangular. Subgenital plate much longer than broad, widened posteriorly, with the lateral margins slightly convex; apex rounded, bisinuate, with a small projection in the middle. Upper valves of the ovipositor with short, strongly recurved, rather obtuse apices and not very sharp margins. Lower valves with the basal part about as long as broad; apical part without lateral teeth, with widely rounded lateral angles; apices feebly decurved, short, acute.

Genotype: *Pachytylus pardalinus*, Walk.

Key to the Phases of Locustana pardalina, *Walk.*† (fig. 5).

1 (2) The average size smaller; the males much smaller than the females. Pronotum more compressed laterally between the shoulders, but less constricted before the middle; median keel more raised, not lower in prozona than in metazona; fore margin more or less projecting in the middle; hind angle sharp. Elytra shorter and narrower, with the margins almost straight and parallel, with the apex obliquely truncate; discoidal area narrower, parallel-sided, with the false vein straight and not incrassate. Coloration of larvae, as well as that of the adults, very variable, but the larvae are never coloured black and red. Both larvae and adults occur singly and in loose swarms. .. .. ph. *solitaria*, n. ph.

2 (1) The average size larger; the males only a little smaller than females. Pronotum not compressed laterally between the shoulders, but strongly constricted before the middle; median keel less raised, in prozona distinctly lower than in the metazona; fore margin straight; hind angle rounded. Elytra broader and also longer, with the margins convex, and the apex obliquely rounded; discoidal area broader, with the sides sinuate, and the false vein distinctly incrassate and sinuate. Coloration of the larvae uniformly black and red. Both larvae and adults occur in dense swarms ph. *pardalina*, Walk.

* The terminology of the parts of the genitalia adopted here is that of L. Chopard (Recherches sur la conformation et le dévelopment des derniers segments abdominaux chez les Orthoptères.—Thèses présentées a la Faculté de Sciences de Paris; Série A, No. 847, 1920).

† See the footnote on page 161.

ON NEW SPECIES OF CURCULIONIDAE ATTACKING FOREST TREES IN INDIA.

By Guy A. K. Marshall, C.M.G., D.Sc.

Subfamily Brachyderinae.

Sympiezomias beesoni, sp. nov. (fig. 1).

♂♀.—Black; the head and rostrum with thin blue-grey scales; the prothorax with rather sparse dull blue scales on the dorsum, the sides entirely clothed with dense metallic green scales; the disk of the elytra as far as stria 4 covered mainly with blackish scaling, more or less interspersed with green scales, which are sometimes denser along the suture; beyond stria 4 the sides are clothed with dense pale green scaling almost to the margin, the inner edge of the green area being very irregular; the lower surface with dense greyish green scaling.

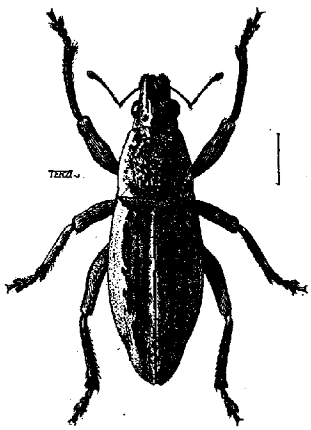


Fig. 1. *Sympiezomias beesoni*, sp. n.

Head with coarse punctation that is usually confluent longitudinally, and often with a very faint broad transverse impression behind the eyes; the vertex rarely with a median stria, but usually with a central fovea. *Rostrum* a little longer than its basal width, shallowly impressed in the middle, with the usual short median furrow, which is not continued on to the forehead, the carinae on each side well marked and parallel. *Antennae* piceous; joint 1 of the funicle slightly longer than 2. *Prothorax* a little broader than long, narrower in front than behind, broadest about the middle, the sides gently rounded; with coarse confluent punctation above, the interspaces

finely and sparsely punctate, without any dorsal stria or impressions; the setae very short, flattened and recumbent. *Elytra* narrowly ovate in ♂, only slightly broader in ♀, with the basal margin strongly raised and the humeral fold not very prominent, the apices not mucronate in either sex; the striae strongly punctate, the intervals slightly convex and of even height, except that interval 1 is somewhat raised at the apex; the flattened setae short, recumbent and inconspicuous on the basal half, longer and more curved behind. *Legs* with the hind tibiae not denticulate internally.

Length, 7–8·75 mm.; breadth, 2·75–3·5 mm.

MADRAS: S. Malabar, Nilambur, 5 ♂♂, 14 ♀♀, vii.1918 (*C. F. C. Beeson*); S. Malabar, Nadengayam, 2 ♂♂, 1 ♀, xi.–xii.1917 (*N. C. Chatterjee*).

Owing to its green scaling and non-mucronate elytra this species comes nearest to *S. frater*, Mshl., which, however, has the whole upper surface with uniform green scaling; the latter also differs in having no median impression on the rostrum, the eyes are less convex, the pronotum is much more finely sculptured, and the intervals on the elytra are flatter.

These weevils were found feeding on the leaves of young teak, and in some cases defoliating the trees.

Subfamily ALCIDINAE.

Alcides dipterocarpi, sp. nov. (fig. 2).

♂ ♀.—Colour red-brown, the head, rostrum, prothorax and the humeral angles of the elytra blackish; the elytra very sparsely set with small narrow pale scales, and without any squamose markings.

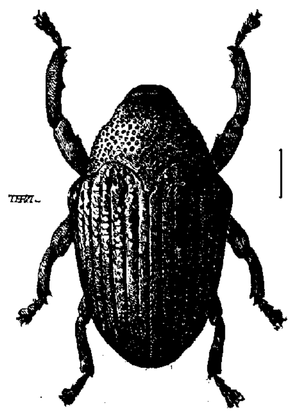


Fig. 2. *Alcides dipterocarpi*, sp. n.

Head coarsely and confluently punctate, with a shallow furrow just above each eye, and the forehead broadly but shallowly impressed. *Rostrum* as long as (♂) or a little longer than (♀) the front femur, parallel-sided from the base to the middle, then narrowing slightly and widening again to the apex, which is a little broader than the base; coarsely and closely punctate throughout, the punctures on the apical

half scarcely smaller than those at the base, with a shallow elongate median fovea above the insertion of the antennae, and with a smooth median line on the apical half only; the sides clothed in the basal half with spatulate scales that are fringed at the apex; ♂ without any projection on the submentum. *Antennae* with joint 1 of the funicle about as long as the next three together, 4–6 subequal and as long as broad, 7 densely squamose and a little longer than its apical width. *Prothorax* nearly twice as broad as long, broadest at the base, the sides gently rounded and markedly constricted near the apex, the dorsum closely set with low convex granules, except the apical area, which is strongly punctate; each granule bearing a forwardly-directed seta (usually bifid) on its anterior edge, and the sides of the apical area with numerous fan-shaped plumose scales, a few of which occur also on the median basal lobe. *Scutellum* small, transverse, tilted forwards, and not at all enclosed in front by the elytra. *Elytra* broadly heart-shaped, scarcely longer than the width at the shoulders, which are obtusely prominent; the striae containing round, deep punctures, which are for the most part separated by more than their own width and become much shallower behind; the intervals broader than the striae, convex, transversely rugose, but not granulate, and sparsely set with small setiform scales, which are often bifid, trifid or quadrifid. *Legs* comparatively short and stout, and thinly clothed with narrow, cleft scales; the hind legs unusually short, so that when outstretched the femur reaches only the apex of ventrite 6 (4th visible), and the tibia exceeds the elytra only by its apical third; the tooth on the front femora of very unusual shape (fig. 3), being in the form of an irregularly trifid

Fig. 3. Front femur and tibia of *Alcides dipterocarpi*, sp. n.

lamina, that on the mid-femora truncate at its apex and with two minute teeth on its external edge, that on the hind femora very small and simple; the front tibiae with a stout median tooth on the inner edge and a subapical one of almost equal size, the mid-tibiae with a subapical tooth but no median one, and the hind tibiae simple. *Venter* clothed with cleft scales, which only partly conceal the integument; ventrite 7 (last visible) with a large rounded median impression in the ♂.

Length, 6·5–7·2 mm.; breadth, 4·25–4·8 mm.

United Provinces: Dehra Dun, bred from seeds of *Dipterocarpus*, vii.1911.

Described from four specimens.

The rhomboidal outline and general structure make this species look like a very small *A. crassus*, Pasc., from the Andamans; but the latter differs, *inter alia*, in having a median internal tooth on all the tibiae, the intervals on the elytra are quite smooth and sparsely punctate, the tooth on the fore femora is triangular with a denticulate outer edge, and the ♂ has two tufts of setae on ventrite 7.

There are several closely allied, and apparently undescribed, species in Malaya, from all of which *A. dipterocarpi* may be distinguished by the peculiar form of the tooth on the front femora (fig. 3).

A. morio, Heller, from South India, is also of very similar appearance, but the elytra are much less narrowed behind, the front coxae are closely approximate, and all the tibiae lack the median tooth and the subapical one is inconspicuous.

Subfamily Cryptorrhynchinae.

Mecistocerus fumosus, sp. nov. (fig. 4).

♂ ♀.—Colour black, with dense blackish or very dark sooty brown scaling above, sometimes sparsely variegated with lighter brown scales; the lower surface with dense sandy brown scaling, the venter with a very broad, median, dark brown stripe throughout.

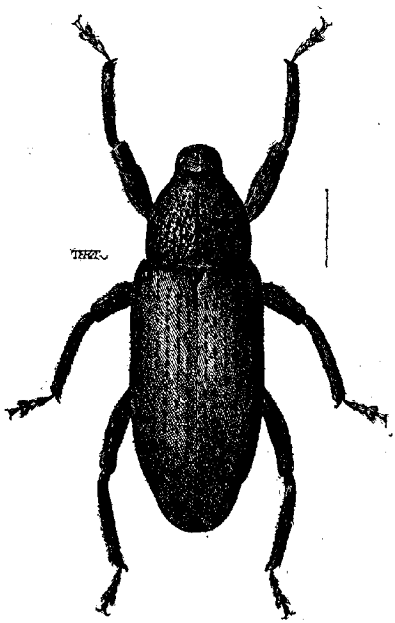


Fig. 4. *Mecistocerus fumosus*, sp. n,

Head with the vertex bare and with coarsely reticulate punctures; the anterior part densely clothed with curled scales, completely hiding the integument, which is much more finely sculptured than the vertex, bearing shallow larger punctures interspersed with much smaller ones; the frontal fovea very deep and elongate, the scales between it and the eye mostly erect. *Rostrum* of ♂ blackish in the basal half and red-brown towards the apex, coarsely punctate towards the base and there tricarinate dorsally, the apical part finely and sparsely punctate, the antennae inserted at the middle; of ♀, paler, a little longer and more slender, more finely punctate throughout, and with the antennae inserted behind the middle. *Antennae*

red-brown, the funicle sparsely clothed with recumbent pubescence, the joints clavate, the two basal ones equal, the remainder slightly and progressively diminishing in length, all of them being longer than broad, except 7, which is about as broad as long; the club subcompressed, markedly broader than the funicle, as long as the three preceding joints together, the first joint of the club as long as the remainder. *Prothorax* with the sides subparallel from the base to the middle, thence roundly narrowed to the apex and without any apical constriction; the dorsum flattened, with the usual very large and deep reticulate punctures, diminishing in size and depth anteriorly, the interspaces shiny, not setose, and with squamiferous punctures, without any real carina, but with a median undulating impunctate line that nearly reaches the base and apex; the scaling on the disk rather thin and recumbent, the scales on the sides larger, denser and slightly raised, and a sharply defined line on the pleura between the dark dorsal and pale ventral scaling. *Scutellum* trapezoidal, broadest behind, about as long as its apical width, markedly flattened and sparsely punctate. *Elytra* unusually flattened, the shoulders prominent; the posterior callus distinct but obtuse; the intervals plane, not elevated or granulate at the base, a little broader than the large deep punctures, which are partly hidden by the dense scaling; when abraded the transverse septa between the punctures are seen to be raised a little higher than the intervals between the rows; the scales very dense, suberect, and with the tips curved downwards, the scale-like setae so short in the male as to be hardly distinguishable from the scaling, a little longer and obliquely raised in the ♀. *Legs* with blackish scaling, except on the basal half of the femora, where it is light brown; the upper apical angle of the hind tibiae prominent, forming a sharp right angle. *Venter* densely squamose at the sides, more thinly so in the middle, with scattered raised squamiform setae; ventrites 3, 4 and 7 (nominally 1, 2 and 5) with numerous large deep punctures, the interspaces with fine scattered punctures, ventrites 5 and 6 each with a single transverse row of larger shallow punctures.

*Genitalia** of ♂ (fig. 5) with the median lobe almost parallel-sided, with a very

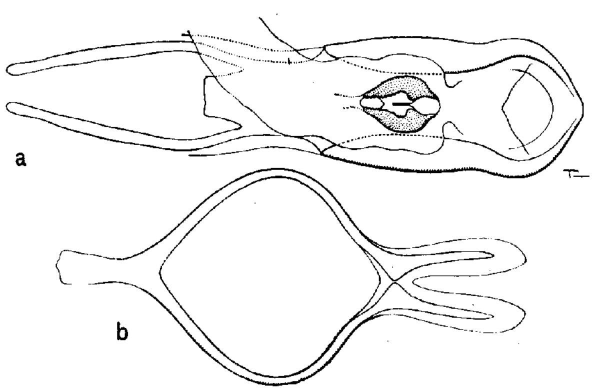


Fig. 5. Genitalia of *Mecistocerus fumosus*, sp. n., ♂ *a*, aedoeagus; *b*, tegmen.

slight lateral sinuation near the apical third and the apex broadly rounded, only the entire margin being heavily chitinised (probably immature); the unevertted sac

* The terms used are those suggested by Dr. D. Sharp, F.R.S. (Trans. Ent. Soc. Lond. 1918, pp. 209-222.

containing a pair of large lunate chitinous plates about the middle, the surface of the sac around them being closely studded with asperities, and no plates at the median orifice ; the tegmen with the ring not closed in the normal manner, but the chitinous rim continued vaguely into the corresponding dorsal lobe on each side, the lobes united for a short distance at the base and a little shorter than the length of the ring, the strut being only half this length. *Genitalia* of ♀ with a rather irregular, oblong chitinous patch in the wall of the vagina opposite its junction with the oviduct, and a similar broad **V**-shaped plate adjoining it anteriorly ; the spermatheca (fig. 7, *d*) very broadly comma-shaped, the apex obtusely rounded, and the accessory gland twice as long.

Length, 5·4–11 mm. ; breadth, 2·2–4·8 mm.

UNITED PROVINCES : W. Almora div., Kumaon, on *Pinus longifolia* (*H. G. Champion*—type) ; Ranikhet, Kumaon, bred from *P. longifolia* (*H. G. C.*). PUNJAB : Dalhousie Range, Chamba State, bred from *P. longifolia* (*C. F. C. Beeson*).

Its remarkable dark sooty colouring and flattened upper surface distinguish this species from all its Indian congeners.

The species of this genus possess a stridulatory apparatus, which is the same in the two sexes, and consists of a file formed of transverse striae at the apex of each elytron on the lower surface ; the scrapers that play on these files are situated on the seventh abdominal tergite and consist of two longitudinal rows of small, rather widely spaced granules.

Genus **Rhadinomerus**, Fst.*

In his revision of the African species of *Mecistocerus* and *Rhadinomerus* (Ent. Tidsk. xxv, 1904, p. 186) Prof. K. Heller treats the latter genus as merely a subgeneric division of *Mecistocerus*. I agree with him that the supposed differences in the structure of the venter used by Faust are quite unreliable ; but this does not apply to the form of the femora. In *Mecistocerus* these organs are clavate, being markedly narrowed towards the base, whereas in *Rhadinomerus* they are sublinear, being but little or not at all narrowed at the base ; moreover, as Faust indicated later (Ann. Mus. Civ. Genova, xxiv, 1894, p. 279, note), the species of *Mecistocerus* can be distinguished by the presence of an elongate bare shiny patch at the base of the femora on the dorsal edge. But a more important point, which has hitherto been overlooked, is that *Rhadinomerus* entirely lacks the apical stridulatory apparatus that is present in both sexes of *Mecistocerus* ; and, finally, in females of the latter genus the eighth abdominal tergite is as long as or longer than broad, whereas in *Rhadinomerus* it is distinctly transverse. On these grounds it seems desirable that Faust's genus should be retained unless these characters are shown to be unstable.

Rhadinomerus bombacis, sp. nov. (fig. 6).

♂♀.—Colour black ; the prothorax with sparse, large, pale scales, which often form a narrow median line and an indefinite lateral one on each side ; the elytra with very dense brown scaling, variegated with a few pale spots and transverse blackish

* Faust, Stett. Ent. Zeit. 1892, p. 215.

patches ; the lower surface with a few sparse pale scales, especially towards the sides, and obliquely raised flattened setae down the middle.

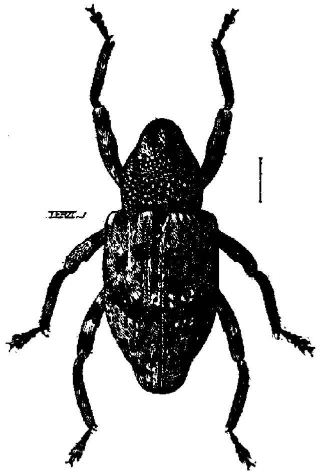


Fig. 6. *Rhadinomerus bombacis*, sp. n.

Head coarsely reticulate on the vertex, the forehead with dense recumbent scales, which are larger behind than in front and partly conceal the median furrow, which is rather shorter and shallower than usual. *Rostrum* with the usual four coarsely punctate furrows and three narrow carinae at the base ; the antennae inserted a little in front of the middle in ♂ and a little behind it in ♀. *Antennae* with the funicle clothed with dense, erect pubescence ; the comparative lengths of the funicular joints, beginning with the longest, are as follows : (1, 2) (3, 4) (5, 6) 7, all being longer than broad except 7, which is as broad as long or slightly transverse ; the club only slightly broader than the funicle, its first joint not longer than the second. *Prothorax* a little broader than long, with the sides very gently rounded, broadest about the middle, very slightly narrowed behind and much more so in front, with a shallow constriction near the apex ; the dorsum, except the apical area, set with very large, deep, reticulate punctures, and sometimes with a trace of a much abbreviated median ridge ; the punctures on the pleurae smaller and much shallower and with the intervals duller and more punctate ; the pale scales much larger than those on the elytra, oblong, convex and veined ; at the base of each puncture a suberect dark spatulate seta directed forwards. *Scutellum* small, rounded, very convex and prominent. *Elytra* subcordate, much broader than the prothorax at the shoulders, which are roundly rectangular, with the sides subparallel from the shoulders to the middle and rather abruptly narrowed behind, being markedly constricted at some distance before the apex ; the large deep subquadrate punctures becoming much shallower behind ; the slightly convex intervals as broad as the punctures and a little higher than the septa between them, with indistinct granules, which are more evident near the base, where the intervals are rather higher, each granule bearing a slightly raised short scale-like seta. *Legs* with dense, light brown scaling ; all the femora with a faint, pale dorsal patch beyond the middle, behind which on the posterior pairş is a large dark patch ; the tibiae with the basal half darker, except for a pale dorsal

spot at the extreme base. *Abdomen* with coarse deep punctures on ventrites 3, 4 and 7 (nominally 1, 2 and 5), the punctures on the two former being denser on the disk than at the sides; ventrites 5 and 6 impunctate and with the anterior edge crenulated.

Genitalia of ♂: the median lobe (fig. 10, *c*) oblong, troughlike and very slightly narrowed towards the base, only lightly chitinised, except the inflexed lateral margins and a transverse strip close to the apex, the latter area being dispersely punctate, the apex broadly rounded, the base forming a sharp right angle on each side, and the median orifice membranous and inconspicuous; the median struts slender, two-thirds longer than the lobe, with a strong double sinuation in the basal third, and connected together for a short distance at the base by an indefinite extension of the lightly chitinised floor of the lobe; the uneverted sac extending between the struts to the end of the sinuated part, containing a small, median, lanceolate, chitinous patch in the lobe close to its base, and the transfer-apparatus at the extremity of the sac composed of two short juxtaposed hairpin-shaped pieces; the tegmen (fig. 11, *c*) with the strut a little shorter than the ring, and this again shorter than the lobes, which are fused together for a very short distance at the base; the spiculum twice as thick as the median struts and slightly dilated at the apex, the basal fork forming a very wide angle, one branch being twice as long as the other and abruptly curved at its apical third. *Genitalia* of ♀: spermatheca as shown (fig. 7, *a*).

Length, 3·8–6·5 mm.; breadth, 1·8–3·5 mm.

UNITED PROVINCES: Pathri, Sarahanpur, bred from logs of *Bombax malabarica*, xii.1917–iv.1918 (*C. F. C. Beeson*).

BIHAR & ORISSA: Singhbhum, from *Bombax malabarica*, i.1921 (*Beeson*).

Described from 24 specimens.

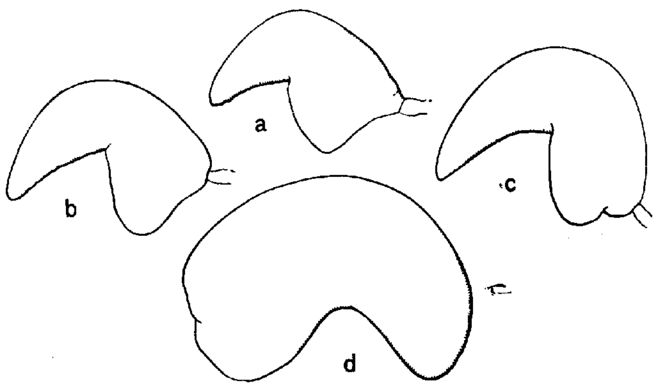


Fig. 7. Spermatheca of (*a*) *Rhadinomerus bombacis*, sp. n.; (*b*) *R. subfasciatus*, sp. n.; (*c*) *R. malloti*, sp. n.; (*d*) *Mecistocerus fumosus*, sp. n.

Rhadinomerus diversipes, sp. nov. (fig. 8).

♂ ♀.—Head and prothorax blackish brown; elytra, venter and legs red-brown; the prothorax with the apical area densely clothed with pale brown scales and

a few similar scales scattered over the disk, and with short, erect, dark setae; the elytra rather thinly clothed with uniform pale brown scales (sometimes variegated with paler spots), and with obliquely raised pale squamiform setae; the sternum with sparse, pale, fine erect setae, the venter with a very few pale scales and with flattened, erect, pale setae.

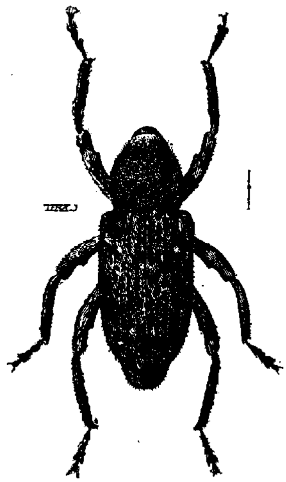


Fig. 8. *Rhadinomerus diversipes*, sp. n.

Head bare and coarsely but shallowly reticulate on the vertex; the forehead on a slightly lower plane, with much shallower and smaller punctures, and with dense pale scales; the frontal furrow very broad and deep. *Rostrum* tricarinate at the base, as usual, with a small patch of raised pale scales in the middle of the base and some erect, pale, squamiform setae; the antennal insertion at (♀) or beyond (♂) the middle. *Antennae* testaceous, with the apical half of the funicle clothed with sparse, recumbent pubescence; the funicular joints in order of diminishing length: (1, 2), 3, 4, 5, (6, 7); 5 as long as broad, 6 and 7 slightly transverse, the rest longer than broad; the club with the basal joint a little shorter than the rest together. *Prothorax* a little broader than long (11:9), with the sides rounded, broadest at the middle, slightly narrowed to the base and shallowly constricted at the apex; the reticulate punctures not very large, but deep; the interspaces dull, finely coriaceous, and sloping inwards towards the puncture, each bearing a single erect, compressed, dark seta; the median carina reduced to a very short sinuous line in the middle, and sometimes almost obliterated. *Scutellum* almost circular, strongly convex, shiny, and with a few short recumbent hairs. *Elytra* subcylindrical, shallowly constricted close to the apex and with an obtuse posterior callus; the oblong punctures deep and diminishing behind, each covered by an oblong horizontal scale attached to the front margin, and on each side a small blackish prominence within the puncture; the intervals about as broad as the punctures, somewhat raised and rugulose close to the base, but almost smooth elsewhere; the scales varying from oval to oblong, not sufficiently dense as to conceal the entire integument, and shorter than those on the apical area of the prothorax; the setae compressed, obliquely raised, and in widely spaced rows. *Legs* with not very dense, uniformly pale brown scales; the

apex of the hind tibiae of the ♂ alone produced inwardly almost at right angles to the tibia in the form of a lamina (fig. 9), having at its apex two short teeth representing

Fig. 9. Hind tibia of *Rhadinomerus diversipes*, sp. n. ♂.

the uncus and mucro, the former being the longer. *Abdomen* with very large separated punctures on ventrite 3 (1st visible), the punctures being at most two deep on the shortest portions (behind the coxae); ventrites 4–6 with only a few much smaller punctures close to the lateral margins; ventrite 7 coarsely and closely punctate; 5–7 with the anterior edge very broadly emarginate and bearing a close fringe of short hairs, the emargination forming a well-marked obtuse angle at each end.

Genitalia of ♂: the median lobe (fig. 10, *a*) oblong, parallel-sided, and moderately

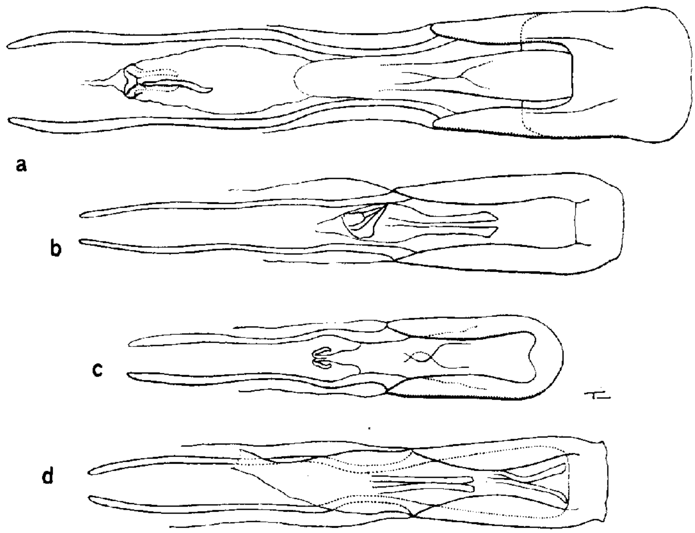


Fig. 10. Male genitalia (median lobe) of (*a*) *Rhadinomerus diversipes*, sp. n.; (*b*) *R. malloti*, sp. n.; (*c*) *R. bombacis*, sp. n.; (*d*) *R. subfasciatus*, sp. n.

chitinised throughout, except for an apical hyaline area which is broadly truncate, the base sharply angulate on each side, the median orifice at about the middle of the lobe, and the apical half with a few sparse punctures; the median struts slender, gently sinuous throughout, and half as long again as the lobe, with which they do not definitely unite but merge gradually into the lateral edges of an abruptly narrowed,

indefinite, basal chitinous extension of the floor of the lobe; the uneverted sac extending between the struts for three-fourths of their length, its terminal third covered with asperities, the transfer-apparatus conspicuous and in the form of two juxtaposed crook walking-sticks with the crooks turned outwards; the tegmen (fig. 11, *a*) with the proportionate lengths of the strut, ring and dorsal lobes as 4 : 2·5 : 5, the lobes being fused together for one-third of their length from the base; the spiculum as broad as the tegminal strut, widely dilated at the apex, and the basal fork forming a right angle with the branches nearly equal in length.

Length, 3–5·2 mm.; breadth, 1·4–2·4 mm.

UNITED PROVINCES: Lachiwala, Dehra Dun, bred from *Eugenia jaman*, x.1914 (*C. F. C. Beeson*—type), and from *Shorea robusta*, xi.1915 (*Beeson*); Surajbagh, Dehra Dun, bred from *Eugenia jaman*, xi.1915 (*Beeson*); Jubberkhet, Dehra Dun, bred from *Shorea*, xii.1915–i.1916 (*Beeson*).

Described from 8 specimens.

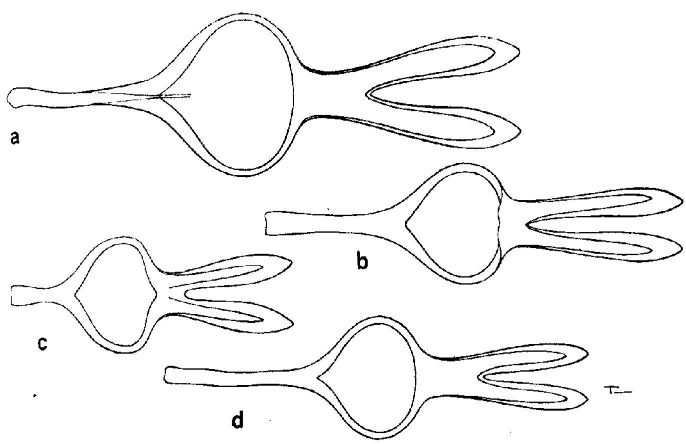


Fig. 11. Male genitalia (tegmen) of (*a*) *Rhadinomerus diversipes*, sp. n.; (*b*) *R. malloti*, sp. n.; (*c*) *R. bombacis*, sp. n.; (*d*) *R. subfasciatus*, sp. n.

Rhadinomerus malloti, sp. nov.

♂ ♀.—Head and prothorax blackish, the latter with yellowish brown scales on the apical area only; the elytra piceous, irregularly mottled with lighter and darker brown scaling; the lower surface without true scales, but sparsely set with short and comparatively fine setae.

Extremely similar to *R. diversipes*, but distinctly broader in proportion to its length. In that species the intervals between most of the punctures on the prothorax are flattened and tilted inwards towards the puncture, so that the ridge is on the outer or posterior edge; in *R. malloti* these intervals are normally convex with the ridge approximately in the middle. The scales in *R. diversipes* are oblong, with the apex truncate or broadly rounded; in *R. malloti* they are narrowly ovate or lanceolate, with the apex pointed, and the setae are distinctly narrower. In the present species ventrite 3 (1st visible) is more closely punctate, the punctures being three deep behind the coxa; ventrite 4 is also coarsely punctate, but less densely so than

3 ; 5 and 6 sometimes bear a single transverse row of punctures ; 5–7 have the anterior margin only shallowly sinuate and without a fringe of hairs, the sinuation not being angulated laterally. The hind femora bear a dark patch in the middle, the tibiae are all darker on the basal half, and the hind pair in the ♂ have the uncus normal.

Genitalia of ♂: the median lobe (fig. 10, *b*) with the sides straight and very gradually diverging from the base to beyond the middle, then gently rounded to the apex, which is broadly truncate and a little wider than the base, the lateral angles of which are obtuse, the greatest width at one-fourth from the apex ; the heavy chitinisation is confined to the lateral margins and a slightly narrower transverse band close to the apex, the rest being almost hyaline ; the median struts slender, half as long again as the median lobe, gently sinuous throughout, distinctly uniting with the sides of the lobe, and the connecting membrane between them at the base hardly chitinised ; the unverted sac extending inwards for only one-fourth the length of the struts and without apparent asperities, the transfer-apparatus rather large and with two awl-shaped processes ; the tegmen (fig. 11, *b*) with the proportionate lengths of the strut, ring and dorsal lobes approximately as 3 : 2 : 4, the lobes being united only at their extreme base ; the spiculum as wide as the tegminal strut and only slightly widened at the apex, with one arm of the basal fork about half as long as the other and forming an obtuse angle with it. *Genitalia* of ♀: the spermatheca as shown (fig. 7, *c*).

Length, 4·4–6 mm. ; breadth, 2–2·75 mm.

United Provinces : Lachiwala, Dehra Dun, bred from *Mallotus philippinensis*, x.1914 (*C. F. C. Beeson*).

Described from 12 specimens.

Rhadinomerus subfasciatus, sp. nov.

♂ ♀.—Colour piceous black, with the apex of the rostrum and tarsi paler ; the extreme base of the rostrum densely, the forehead less closely, clothed with cinnamon scales ; the apical area of the prothorax with similar elongate scales, the remainder not squamose, but with erect, compressed dark setae ; the elytra variegated with more or less confluent spots of cinnamon-coloured scaling, which usually form a broad, broken transverse band behind the middle, the dark areas thinly clothed with much smaller dark scales ; the lower surface without true scaling, but with sparse erect pale setae.

The other external characters as described for *R. diversipes*, except the following: *Scutellum* of similar shape, but quite devoid of hairs. *Elytra* with the setae a little longer and distinctly narrower ; the punctures not covered by a scale, this being replaced by a very minute seta. *Legs* with the scales distinctly darker and smaller on the basal than on the apical half of the tibiae ; the hind femora with a dark median patch ; the uncus of the hind tibiae of the male normal. *Abdomen* with ventrite 3 (1st visible) much more closely punctate, the punctures being three deep behind the coxae ; ventrite 4 also bearing strong punctures, but much smaller and more widely spaced than those on 3, and less numerous in the ♀ than in the ♂.

Genitalia of ♂: the median lobe (fig. 10, *d*) shaped just like that of *R. malloti*, but the chitinised lateral areas more produced inwards in the middle, so that the hyaline median area is shaped like an hour-glass ; the median struts slender, three-fourths longer than the lobe, strongly bisinuous in the basal third, distinctly uniting with the sides of the lobe, and connected together by a lightly chitinised membrane in the basal fifth ; the uneverted sac extending inwards for nearly half the length of the struts, set with asperities in the terminal area, but without any obvious transfer-apparatus or other chitinous structure ; the tegmen (fig. 11, *d*,) with the

proportionate lengths of the strut, ring and dorsal lobes as 3·5 : 2 : 3, the lobes fused together for nearly half their length; the spiculum similar to that of *R. malloti*, but the fork forming almost a right angle. *Genitalia* of ♀: the spermatheca as shown (fig. 7, *b*).

Length, 3·5–4 mm.; breadth, 1·5–2 mm.

UNITED PROVINCES: Jhabberkhet, Dehra Dun, bred from log of *Shorea robusta*, vi.1916 (*C. F. C. Beeson*—type); Kotdwara, Lansdowne Division, bred from *Shorea*, ix.1917. PUNJAB: Thano, Siwalik Hills, bred from *Eugenia*, vi.1918 (*Beeson*).

The three previously described Indian species of *Rhadinomerus* (Faust, Ann. Mus. Civ. Genova, xxxiv 1894 (1895), pp. 279–281) are known to me from description only. *R. granicollis* is distinguished from all the species here described by its granulato-punctate prothorax and the elytra bear spatulate suberect setae. *R. conciliatus* is characterised by its cylindrical elytra, the intervals of which bear minute granules and erect hairlike setae, the prothorax being oblong and parallel-sided. The most distinctive features of *R. contemptus* appear to be that the prothorax is roundly dilated before the middle and that it is densely squamose both at the sides and at the apex.

Rhadinopus buteae, sp. nov. (fig. 12).

♂ ♀.—Colour black or red-brown, with dense, pale brown scaling and very broad erect scale-like setae; the pronotum with an indefinite blackish patch on each side of the middle line near the base and a few white setae in the middle of the disk; the elytra each with an ill-defined oblique whitish band running from about the middle of the suture towards the shoulder, but terminating on interval 5, and just behind this on interval 2 an elongate patch of dense erect blackish setae; the lower surface rather thinly clothed with obliquely raised broad pale scales.

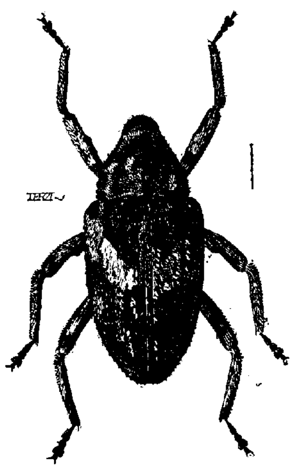


Fig. 12. *Rhadinopus buteae*, sp. n.

Head closely punctate on the vertex, each puncture containing a minute seta; the forehead not impressed, more coarsely punctate and with dense scales, which are recumbent behind and erect in front, the interocular space parallel-sided. *Rostrum*

rather strongly curved, strongly punctate at the base, and there rather more squamose and with the median carina a little more prominent in the ♂; the antennal insertion at (♀) or a little beyond the middle (♂). *Antennae* with joint 2 of the funicle a little longer than 1, the remainder progressively diminishing and all longer than broad except 7, which is as long as broad and bead-like; the club very elongate, as long as the 5½ preceding joints, cigar-shaped. *Prothorax* broadest at the base, the sides gently rounded, not constricted at the apex; the dorsum strongly and closely punctate, without any median carina, the spaces between the punctures flat, shiny and impunctate; the scales large and subcircular, but scarcely overlapping, those in the middle of the disk smaller and exposing more of the integument; the very broad, erect spatulate setae truncate at the apex. *Scutellum* almost circular, slightly convex and densely clothed with small scales. *Elytra* ovate, broadest at the shoulders, which form a rounded, obtuse angle, and scarcely impressed before the apex; the comparatively small punctures almost hidden by the dense scaling, each one being covered by a large scale and set in shallow striae; the intervals a little broader than the striae, not carinate on the disk, but rather convex and somewhat rugulose or subgranulate, especially towards the base, only interval 9 carinate in the posterior half; the scales closely overlapping, and each interval with a row of very stout, erect, scale-like setae, these being more numerous on intervals 2, 3 and 5. *Legs* with uniform pale brown scaling and recumbent setae, the latter being erect only along the dorsal edge of the tibiae; the dorsal edge of the femora straight and the inferior tooth small; the tibiae markedly narrowed from base to apex, and with no angulation externally at the apex.

Length, 6 mm.; breadth, 3 mm.

PUNJAB: Rani Range, Siwalik Hills, bred from logs of *Butea frondosa*, iv.1918 (*C. F. C. Beeson*).

Described from 8 specimens.

In the ♂ the last visible ventrite has a shallow impression at the apex, with a small tubercle on each side of it bearing a single seta; in the ♀ this ventrite bears a shallow transverse impression at a little distance from the apex.

From the three previously described Indian species of the genus, *centriniformis*, *consputus* and *parcus* (Faust, Ann. Mus. Civ. Genova, xxxiv, 1894 (1895), pp. 289-90) the present species may be distinguished by the common pale **V**-shaped mark on the elytra and by its tapering tibiae. *R. centriniformis* and *consputus* also differ, *inter alia*, in having all the setae recumbent, interval 3 on the elytra strongly carinate on the declivity, the dorsal edge of the posterior pairs of femora markedly sinuate, the seventh ventrite (last visible) of the ♂ without tubercles, tergite 7 of the ♂ almost truncate at the apex and 8 densely squamose (in *buteae* 7 of the ♂ is deeply sinuate at the apex and 8 is bare and shiny). *R. parcus* differs in having the pronotum granulato-punctate, the scutellum is punctiform and shiny, the punctures on the elytra bear only a fine seta instead of a broad scale, and the intervals are narrowly carinate.

In this genus the stridulatory apparatus of the ♂ consists of the usual files towards the apex of the elytra near the suture, the scraper being formed by two very minute, short transverse carinae on the apical edge of the seventh tergite, which are very easily overlooked. In the ♀ the files are on the seventh tergite, instead of on the elytra, and are composed of comparatively widely separated longitudinal striae, the ridges between them being very finely and transversely striate. The apparatus in both sexes is similar to that found in the European *Cryptorrhynchus lapathi*; the statement made by Dr. C. J. Gahan (Trans. Ent. Soc. Lond. 1900, p. 450) and repeated by myself (Fn. Brit. India, Curculionidae, i, p. 17), that there are no stridulatory organs in the ♀ of this species is erroneous.

Subfamily ZYGOPINAE.

Osphilia odinae, sp. nov. (fig. 13).

♂ ♀.—Colour piceous brown, rather thinly clothed above with pale hair-like scales, asymmetrically variegated with subdenuded patches; the lower surface densely covered with white scales, mostly linear, but some ovate; the base of the rostrum and a broad stripe below each eye with dense, narrow, whitish scales. The pronotum with pale yellowish scales, all of which are linear except a single row along the extreme base, which are rather shorter and broader; a broad median denuded stripe, and on each side of it a shorter oblong one narrowly uniting with it not far from the apex, thus forming (very roughly) an inverted trident, externally to which is a very indefinite lateral longitudinal sub-denuded patch; these darker areas thinly clothed with dark recumbent setae. The elytra with the following similar ill-defined and rather variable darker patches: a rounded one on the shoulder, a transverse band before the middle extending from stria 2 nearly to the lateral margin, a broad and very irregular macular transverse band behind the middle, and a rounded juxta-apical spot.

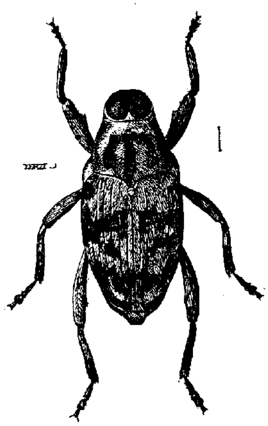


Fig. 13. *Osphilia odinae*, sp. n.

Rostrum as long as the head and prothorax together, entirely red-brown, gradually narrowed from the base to near the apex and thence slightly dilated, the extreme base triangular in section with the apex uppermost; the basal portion coarsely punctate (less so in ♀), but the median line smooth throughout, the punctures on the apical portion very fine and separated in ♀, and longitudinally confluent in ♂; the antennal insertion behind the middle in ♀, at or beyond it in ♂. *Antennae* of ♀ testaceous with only the club blackish, in the ♂ the whole funicle also blackish except joint 1 and the basal half of 2; the funicle with joint 2 as long as or a little longer than 1, the remainder slightly and progressively shortening outwards in the ♀, all longer than broad, except 7, which is as broad as long; in the ♂ joint 2 is strongly clavate, the dilatation being greater on the inner side, which is densely clothed with setae, the remaining joints bead-like and more nearly equal in length than in the ♀; the first joint of the club longer than broad in both sexes. *Prothorax* transverse, the sides gently rounded, broadest before the middle, the base deeply bisinuate;

the dorsal outline almost flat, the dorsum finely but confluently granulato-punctate throughout. *Scutellum* circular, densely clothed with woolly scales having their apices directed forwards. *Elytra* with the intervals broader than the very shallowly punctate striae and finely rugulose; the pale scales very long and narrow, except on the basal half of interval 1, where they are much shorter and broader and pubescent or densely fringed; the scales on the darker areas short, setiform and dark. *Legs* finely rugulose, rather thinly and uniformly clothed with long, narrow, pale scales; the front femora with a long sharp tooth, followed by a low carina bearing a single row of 9 or 10 stiff erect bristles.

Length, 3·25–3·5 mm.; breadth, 1·6–1·8 mm.

United Provinces: Banki, Gorakhpur, bred from *Odina wodier*, v.1918 (*C. F. C. Beeson*—type); Chauk, Gorakhpur, bred from *Cassia fistula*, v.1918 (*Beeson*); Dehra Dun, bred from *Odina wodier*, v.1919 (*B. B. Osmaston*).

Described from 17 specimens.

Only two other species of the genus have been described from the Indian sub-region. *O. brevirostris*, Heller, from Ceylon, is of the same size, but has the rostrum only as long as the prothorax, the joints of the funicle gradually widening outwards, the antennal club pale and with the first joint broader than long, and the elytra clothed with yellow scales and with a white spot at the apex of the suture.

O. egregia, Fst., from Burma, is a much larger insect (6 mm.) with mottled umber and ochraceous scaling on the elytra, and three transverse rows of pale spots on the pronotum.

INSECT PESTS OF VARIOUS MINOR CROPS AND FRUIT TREES IN MAURITIUS.

By D. d'Emmerez de Charmoy,
Entomologist to the Department of Agriculture,
and S. Gebert.
First Scientific Assistant, Division of Biology.

The following paper deals with insect pests of various minor crops and fruit trees in the Colony of Mauritius. The damage caused by most of the pests dealt with is often not very apparent, as many of these crops are not grown extensively, and have not been the object of any special investigation up to the present. If extensive cultivation of any of these should be undertaken, it is clear that there might be created a new environment favourable to increase of the insects, and that the pest problem would then have to be dealt with seriously. Our knowledge of these pests is very deficient, as their life-history and habits have never been studied in detail locally. It is also quite probable that extended cultivation may bring to light many potential pests which at present escape our attention.

The crops dealt with in this paper are all capable of being developed in the future and, for the present, nothing more than a mere enumeration of the pests for which they serve as hosts can be made, except in a few particular cases. These brief notes should only be considered as a preliminary study which will serve as a guide, as well as a warning, to those who are likely to give more extensive attention to these economic plants.

Cotton.

The cotton occurring in the Colony consists merely of a few plants scattered over the island. In former years, as far back as 1847, the plant used to thrive in many localities, where its cultivation was carried out on a moderate scale. The yield and quality of the cotton were good, and no trouble due to insect attack seems to have been experienced. Attempts to grow cotton on a large scale were made in 1911, but owing to various unfavourable conditions, such as bad weather, drought, scarcity of labour, and insect attacks, the enterprise did not succeed.

The Department of Agriculture, which did not exist then, is now taking up the matter, and it is hoped that a certain extension will be given to cotton growing.

The enemies of cotton are mainly cosmopolitan, and most of the chief cotton pests that have been recorded in other parts of the world occur here ; the following have so far been noticed :—

Prodenia litura, F., and *Spodoptera mauritia*, Boisd. These two species of cutworms, though not true cotton pests, are nevertheless polyphagous, and therefore likely to prove injurious to cotton. *Prodenia litura* is the commoner of the two, and proves quite troublesome to garden plants during the hot season. The eggs of this moth are parasitised by a species of *Telenomus* ; the development of the parasite in the egg of the moth takes 21 days, and the proportion of males to females emerging from the eggs is, on an average, 1 to 3.

Cosmophila flava, F. (*xanthindyma*, Boisd.). The caterpillar feeds on the leaves of cotton.

Chloridea obsoleta, F. This polyphagous insect of world-wide distribution, commonly known as the American bollworm, is found here on a great variety of plants, the chief being maize, tobacco, *Hibiscus esculentus, Cajanus indicus*, and various other leguminous plants. It is also a serious pest of pelargoniums, destroying the tender stems and flowers.

Earias insulana, Boisd. The caterpillar is the spotted bollworm of India. It is another cosmopolitan species, and its feeding habits in Mauritius appear to be much the same as those of *Chloridea obsoleta*. It seems, however, to confine its attacks particularly to Malvaceae, and is of rather common occurrence. Twigs, leaves and flower-buds are attacked as well as the bolls.

Platyedra gossypiella, Snd. The pink bollworm is one of the most serious pests of cotton, and although it has not yet been observed on cotton in Mauritius, a few moths have been bred from pods of *Cajanus indicus* and other Leguminosae of the same type.

Pyroderces (Anatrachyntis) simplex, Wlsm. The moth has been obtained from larvae found in cotton bolls.

Dysdercus spp. Of the cotton pests which are found here, the red cotton-stainers, of which two species exist, are by far the most common, and are found on all malvaceous plants, as well as on many others, growing along the coast. As cotton-stainers have done considerable damage in cotton-growing centres, they can probably be looked upon as our most serious potential pest. *Dysdercus* is known to transmit several bacterial diseases. It has already done a good deal of damage to cotton bolls at the experimental plantation of the Department, and is the vector of an internal disease of the bolls similar to that described by Nowell and others in the West Indies.

Aphis gossypii, Glov. This green aphis is common on various garden plants as well as on cotton. It is parasitised by a species of *Aphidius*, and is preyed upon chiefly by a large ladybird, *Chilomenes lunata*, and by Syrphid flies.

Saissetia nigra, Nietn., and *Saissetia hemisphaerica*, Targ. These two scale-insects occur on various plants besides cotton. *S. nigra* is found chiefly on *Hibiscus esculentus*, rubber, mango and various Malvaceae. It is parasitised by two species of Chalcids and by a fungus. These probably keep it in check, as it cannot so far be reckoned as a pest. *S. hemisphaerica* occurs chiefly on citrus, guava (*Psidium*), litchi (*Nephelium*) and *Aristolochia acuminata*.

Achatina fulica. Though not an insect pest, mention may be made of this large snail, locally known as "Couroupa," which also occurs in India and Ceylon, whence it has been introduced here. It was responsible for a good deal of damage to cotton seedlings, when the attempt was made to plant cotton on a large scale in 1911. As the snails are very large, it is not difficult to have the land cleared of them by hand-picking before planting. This should be done in the evening, as the snail has nocturnal habits. Those met with in the daytime are generally found hiding in dark places, or are in copulation. They are most active after the first rains have set in and after sunset.

Tobacco.

Extensive cultivation of tobacco has recently been tried by this Department, and as the results obtained have been very satisfactory, it is thought that tobacco growing may rank among the chief of our minor industries. The variety tried is that which is extensively grown in the island of Réunion. The yields have been satisfactory, and the prepared cigarette tobacco has sold rapidly. Planting is being encouraged by the Department of Agriculture, which is doing everything it can in order that tobacco cultivation may be carried out on a large scale.

Although the insects attacking this plant are not numerous, it is nevertheless useful to record them.

Prodenia litura, F., and *Spodoptera mauritia*, Boisd. The habits of these caterpillars have already been mentioned under cotton. The damage done to tobacco seedlings may be very great.

Coelonia (Sphinx) solani, Boisd. A minor pest.

Phytometra (Plusia) orichalcea, F., and *P. chalcytes*, Esp. These two polyphagous insects feed occasionally on tobacco. A certain amount of damage is caused to seedlings.

Chloridea obsoleta, F. This moth is here the chief pest. The caterpillars eat into the seed-capsules and often cause great damage; they are also found on the leaves.

Thrips sp. Thrips are occasionally found in tobacco flowers, but do no great harm.

Heterodera radicicola. The roots are sometimes so badly infested with eelworms as to cause the death of a good many plants.

Maize.

Maize is another important food crop and its cultivation is being extended yearly, there being now over 5,000 acres under this crop. Though the list of pests is not long, appreciable damage is caused, especially to the cobs and seedlings.

Prodenia litura, F., and *Spodoptera mauritia*, Boisd. These two cutworms damage the seedlings and are occasionally found on the leaves of the mature plant.

Sesamia vuteria, Stoll. Seedlings are badly attacked by the caterpillars of this moth. Its life-history and habits have been worked out and published in a Bulletin on Moth Borers of the Sugar-Cane (Scientific Series, Bulletin No. 5), issued by this Department. Though *Sesamia* is a regular pest of sugar-cane, the moth has a marked preference for maize seedlings, on which it deposits its eggs. As many as three or four egg-batches are inserted between the leaf-sheaths and the stem; these are composed of 15 to 75 eggs. The young larvae tunnel into the stem of the young plant, which soon withers, and the caterpillars then migrate to older plants, in which the rest of their development is passed, the caterpillar sometimes pupating in the stem of the plant.

To gain an idea of the intensity of these attacks, the following is worth noting. In March 1915, 35 acres of maize were planted on an estate, but so many of the plants were destroyed that the yield amounted to that usually obtained from $1\frac{1}{4}$ acres. On another occasion about 800 yards between lines of canes were planted with maize; the plants were examined every day, and showed the following infestation:—

1st day of examination,	90	plants infested and uprooted.
2nd ,, ,,	101	,, ,, ,,
3rd ,, ,,	88	,, ,, ,,
4th ,, ,,	64	,, ,, ,,
5th ,, ,,	164	,, ,, ,,
6th ,, ,,	160	,, ,, ,,
7th ,, ,,	111	,, ,, ,,
8th ,, ,,	120	,, ,, ,,
9th ,, ,,	404	,, ,, ,,
10th ,, ,,	1,925	,, ,, ,,
11th ,, ,,	1,200	,, ,, ,,
12th ,, ,,	1,200	,, ,, ,,
Total	5,627	plants.

It will be seen from this that *Sesamia* is a very serious pest. In addition to boring the stems it also attacks the cobs. The natural enemies of this moth are four in number. *Telenomus* sp. is an egg parasite, which has already been mentioned under *Prodenia*. The life-cycle in the egg of *Sesamia* is the same as in that of *Prodenia*. *Trichogramma australicum*, Gir., is another egg parasite. *Henicospilus antancarus*, Morl., and *Stauropodoctonus mauritii*, Morl., are both parasitic upon the full-grown caterpillar.

Proceras (*Diatraea*) *sacchariphaga*, Boisd., is less common than the former and attacks the plant in the same way.

Aphis maidis, Fitch, is sometimes common on the leaves, but is not a regular pest.

Chloridea obsoleta, F. The caterpillar is often found attacking the tender top part of the stem and also the young ears. It frequently feeds on the silks, sometimes destroying them entirely, in which case the ears become barren, and also bores its way into the cob after having fed on the young grain. Many ears are spoiled in this way.

When maize ears are allowed to remain on the plant until the latter has dried up, the grain is invariably attacked by weevils, *Calandra oryzae*, L., being the chief pest. Damage is also done by *Dinoderus minutus*, F. Over 50 per cent. of the grain may be destroyed before storage. These pests, as well as a Tineid moth, also cause serious damage to stored maize if fumigation is not resorted to. Full details concerning these insects will be found in Bulletin No. 2 of this Department's Scientific Series (Insects Injurious to Stored Grains in Mauritius).

Manioc (*Manihot utilissima*).

Manioc is another important foodstuff, being largely used for stock. The plant thrives in the hot districts, and gives very good returns. A great many varieties, most of them imported lately by the Department of Agriculture, are grown. There are practically no insect pests of the plant.

Lachnosterna (*Phytalus*) *smithi*, Arrow, is an occasional pest in the infested regions.

Saissetia hemisphaerica, Targ., is sometimes found on the leaves, but is a minor pest. A species of *Chionaspis* occurs frequently on the stem.

Sweet Potato (*Ipomoea batatas*).

This tuber is greatly in favour with the poorer classes of the population, and is also an important cattle food. The plant grows well all over the island, the highest yields being obtained in the hotter lowland regions. A great number of varieties are grown, most of which have been imported lately by the Department of Agriculture.

The chief pest of the foliage is a Pterophorid moth, *Trichoptilus wahlbergi*, Z., the larva of which feeds on the leaves, especially the tender parts and buds, and rolls up in the leaf before pupating.

Ercta ornatalis, Dup. This Pyralid moth is another leaf pest.

Herse (*Sphinx*) *convolvuli*, L. The caterpillar is occasionally found on the sweet potato, but cannot be regarded as a pest.

Aspidomorpha obovata, Klug. This Chrysomelid beetle is also an occasional pest, doing no great damage. It lives on various wild species of *Ipomoea*.

Cylas formicarius, F., is by far the worst pest. It is exceedingly common whenever sweet potatoes are grown in mounds, and is then responsible for very serious damage. As many as 50 to 100 larvae may be found in a single tuber. The method of planting sweet potatoes in mounds has only recently been adopted, and the resulting looseness of the soil certainly renders the plants more liable to the attacks of this beetle.

Ambrevades (*Cajanus indicus*).

This plant suffers a great deal from caterpillars, which live in the pods. In certain regions 75 per cent. of the crop is lost. Control measures are difficult to apply, for reasons mentioned further on.

Adoretus versutus, Har. This beetle, which has polyphagous habits, feeds on the leaves of the pigeon-pea, but is not a serious pest.

Lachnosterna (*Phytalus*) *smithi*, Arrow. Plants grown in the infested region are usually visited by *L. smithi*. The damage caused is insignificant, as the plants in the infested areas serve as trap plants, from which the beetles are hand-picked at night.

Icerya seychellarum, Westw., is common enough on almost all the plants of the island, and is only a minor pest of pigeon-pea. Various insecticides in the form of emulsions have been tried against this pest, but the results have never been successful.

Eucalymnatus tessellatus, Sign., is a minor pest of the twigs and attacks various other Leguminosae.

Chionaspis subcorticalis, Green, is occasionally found on the branches of this plant, more especially on the tender twigs, but does not do much harm.

A species of *Botys* is very common on the tender leaves.

By far the worst pests of *Cajanus indicus* are certain Lycaenid butterflies, which are exceedingly common when the plant begins to flower. The eggs are laid on the flower-buds and young pods, and the newly-hatched caterpillar, after having fed for a short time on the surface of the buds and pods, bores its way in. Advantage was taken of this to try to control the insect by spraying the flower-buds and pods with arsenate of lead. The results were not successful, for it was difficult to make the spray adhere to the flower-buds, as these are covered with fine hairs, which will not hold the spray. Moreover, at this time of the year the wind is usually very strong, so that the sprayed material is shaken off the plant before it has time to dry, in spite of its adhering power having been increased by the addition of mucilaginous substances, such as a maceration of *Opuntia* in water. The following is a list of the Lycaenids that feed in the flower-buds and pods :—*Lampides boetica*, L., *Zizera lysimon*, Hb., *Tarucus telicanus*, Lang, and *Nacaduba mandersi*, H.H.D. Of these *Lampides boetica* is the worst pod pest, the others confining their attacks rather to the flower-buds.

Chloridea obsoleta, F., is an occasional pest of pods.

Platyedra gossypiella, Snd., is also occasionally found in pods and is more common than *Chloridea*.

Botys spp. Two species of PYRALIDAE are found in the flower-buds, and more rarely in the pods. These are the most dangerous pests of flower-buds, and are responsible for a great deal of damage.

Pois Sabre (*Canavalia ensiformis*).

Only a few pests are worth recording :—

Thrips are often abundant in the flowers and cause many of these to fall off.

Argyroploce rhynchias, Meyr. The caterpillar feeds in the pods, also attacking the twigs, and may sometimes ruin the whole crop.

Aspidiotus sp. This scale is a minor pest, and is found on the twigs.

Rhopalocampta forestan, Cram., is also a minor leaf pest.

Voheme (*Vigna catjang*) and Haricot Bean (*Phaseolus vulgare*).

Agromyza phaseoli, Coq., is such a regular pest of these plants that their cultivation is almost impossible in certain localities and at certain times of the year.

Remigia (Pelamia) repanda, F. The caterpillar feeds on the leaves of *Vigna catjang*.

Pea (*Pisum sativum*).

Plusia orichalcea, F. The caterpillar is a minor pest of peas, doing some injury to the leaves.

Chloridea obsoleta, F., occurs as a leaf pest.

All the Lycaenid butterflies mentioned under *Cajanus indicus* attack the pea more or less. The chief pest, however, is *Lampides boetica*, L., which is sometimes responsible for great damage.

Pistache (*Arachis hypogaea*).

The pests attacking ground-nuts are not numerous and do not cause very serious damage.

Chloridea obsoleta, F., and *Plusia orichalcea*, F., are the only two worth recording as leaf pests. *Ephestia cautella*, Walk., attacks the fruits, and *Pseudococcus calceolariae*, Mask., is sometimes a serious pest of the roots.

Pumpkins, Melons, Cucumbers, etc.

Cucurbitaceous plants suffer severely from the attacks of the fruit-flies, *Dacus sygmoides*, Coq., and *Tridacus d'emmerezi*, Bezzi.

The caterpillar of a Pyralid moth, *Glyphodes indica*, Snd., feeds on the tender leaves and buds. It is not greatly harmful to the plant itself, but as the leaves are used for human consumption, and as the caterpillars always roll themselves in the leaves, they are troublesome pests.

Aphis gossypii, Glov., is a minor pest.

Cruciferae (Cabbage, Cauliflower, etc.).

The Pyralid moth, *Crocidolomia binotalis*, Z., has proved to be a regular pest of cabbage. The leaves are so badly eaten that they rot *in situ* and are thus rendered unfit for human consumption.

Plutella maculipennis, Curt. Late in the season the leaves of cauliflowers and cabbages are badly attacked by this pest.

Aphis brassicae, L., occurs in abundance at the beginning of the season. Towards the end its numbers are reduced, as it is preyed upon by Syrphid flies, chiefly *Xanthogramma pfeifferi*, larvae of lace-wing flies, and by a large ladybird, *Chilomenes lunata*.

Artichoke.

Two pests occur :—The artichoke moth, *Porpe bjerkandrella*, Thunb., which is very prevalent at times and greatly injures the foliage ; and an Aphid, *Macrosiphum picridis*, F., which is exceedingly common on the leaves and tender parts of the stem, doing serious damage.

Tomato.

The insect enemies of the tomato are the same as those of tobacco and need not be mentioned again. It is worth recording, however, that the eel-worm, *Heterodera radicicola*, is a regular pest and sometimes occasions great losses.

Coconut.

This plant thrives in the coastal regions wherever the land is not rocky. A certain amount of extension is being given to its cultivation in certain parts of the coastal belt, and promising results are being obtained.

The beetle, *Oryctes tarandus*, Oliv., occasionally bores into the tender part of the stem, which it usually enters beneath the basal part of a leaf, just where it begins to stretch away from the stem, and bores a gallery right through. It also bores its way into the mid-rib of the leaf. The galleries in the stem are usually made tangentially, and in such cases, though the tree is not immediately affected thereby, a door is opened for bud-rot. It often happens, however, that the beetle bores its way radially inwards into the growing point; in such a case the health of the palm is affected and immediate death results.

Of all the scales which are found on the coconut palm, the most common is *Diaspis boisduvali*, Sign. It occurs in very great numbers all over the island and is a serious pest. The injury done is very great both to old and young plants, the insect occurring in thousands on a single leaf. Now that a certain extension is being given to the cultivation of the coconut, combative measures will have to be adopted, as the pest is a serious menace to the future of the coconut industry.

Coffee.

Coffee was extensively grown years ago, but its cultivation has had to be abandoned on account of the attacks of leaf disease (*Hemileia vastatrix*). It is, however, cultivated in certain localities for local consumption. Liberian coffee thrives in the colder districts and yields heavily, and if its cultivation is extended good results may be expected, as it is very slightly subject to attacks of *Hemileia*.

Cratopus punctum, Boh. Arabian coffee does not suffer much from the attacks of this weevil, which has a marked preference for the Liberian variety, the leaves of which it devours to such an extent as to cause almost entire defoliation of the plant. It is worth noting that in the upland regions the attacks of *Cratopus* are not serious.

Adoretus versutus, Har., is another leaf pest.

Botys octoguttatus.* The caterpillar feeds in the berry and is rather a serious pest.

Prodenia litura, F., destroys many seedling plants as they come up.

Saissetia nigra, Nietn., and *Saissetia hemisphaerica*, Targ., occur as minor pests.

Coccus viridis, Green, is sometimes found abundantly on the leaves of young plants in nurseries. Infestation begins as soon as the first leaves are fully developed and soon extends to the young leaves as these emerge from the bud stage. In such cases the young plants soon die. The insect also occurs in abundance on older plants, being the most important scale pest.

A small Bostrychid beetle tunnels into the twigs of the coffee plant. The galleries are bored obliquely to a length of 2 to 3 cm., reaching the pith. The attacks are sometimes so bad as to cause the drying up of the infested twigs.

Limes and other Citrus Fruits.

The lime (*Citrus medica* var. *acida*) thrives in many parts of the island, especially in the hotter coastal regions. The crop forms the subject of a small trade on the local market, but is not of sufficient size to be dealt with on an export basis. Experimental trials are being made at present by the Department of Agriculture with a view to extending the cultivation of this plant, and it is hoped that before long lime

* [Possibly intended for *Thliptoceras octoguttalis*, Feld.—Ed.]

products will rank among the chief of our minor industries. Preserved limes are imported from Rodrigues, a dependency of Mauritius, where the trees bear good crops. The crop obtained there is, in fact, too large for the wants of the island, and the excess is salted and sent to Mauritius. Other citrus fruits, such as mandarines, oranges, lemon, shaddock, etc., also grow well and give good returns, so that on the whole the group is of increasing importance locally.

There are many insects that attack these plants, the chief pests being *Papilio demodocus* and the citrus aphis.

Papilio demodocus, Esp. This butterfly, which is known all over Africa as an enemy of citrus trees, is here a most troublesome pest to young plants. The caterpillar destroys the seedlings when they are three or four inches high, and if removal of the larvae from young plants is not practised constantly, considerable damage is done. No great injury is done to full-grown plants. The eggs and larvae are very conspicuous and can be easily removed from seedlings by hand-picking.

Papilio phorbanta, L. The life-history and habits of this butterfly are much the same as those of *Papilio demodocus*. It is less common than the latter and can rarely be reckoned as a serious pest of seedlings. The eggs are always laid on the lower surface of tender leaves; *Papilio demodocus*, on the other hand, seems to deposit its eggs anywhere.

The scale-insects found on lime trees are eleven in number and occur in abundance during the beginning of summer. When the rainy season sets in and the air becomes saturated with moisture, the scales are to a great extent attacked by several parasitic fungi, which gradually destroy them. This statement does not, however, always hold good for the coastal regions, where the heat is excessive and the climate comparatively dry. It is especially there that the presence of scale-insects is felt, for the damage caused is appreciable and the scales occur all the year round. The ten species found are :—

Chrysomphalus aurantii, Mask., and *Chrysomphalus ficus*, Ashm., on the twigs and stems.

Pseudaonidia trilobitiformis, Green, on the leaves.

Chionaspis citri, Comst., on the leaves and tender branches.

Lepidosaphes gloveri, Pack., on the leaves, tender shoots, and fruits.

Saissetia oleae, Bern., on the young shoots and branches.

Saissetia hemisphaerica, Targ., on the leaves.

Coccus viridis, Green, on the leaves and tender twigs. Infestation is sometimes very heavy, two to three hundred larvae and adults occurring on the same leaf. This species is heavily parasitised by two Chalcids, *Diversinervus silvestrii*, Waterst. sp. n., and *Tetrastichus sicarius*, Silv.

Icerya seychellarum, Westw., is a regular pest.

Pseudococcus citri, Risso, is a minor pest.

Pseudococcus filamentosus, Ckll. (*vastator*, Mask.) is commoner than the preceding species.

The buds and flowers are intensely attacked by a species of brownish-black aphis. The damage caused to the flowers is great, as a large proportion of them drop. Seedlings are sometimes infested to such an extent as to cause their growth to be stunted for a time. When such is the case, lateral growths are emitted, to the detriment of the plant.

Eggs and larvae of a Psyllid, *Trioza* sp., are found on the lower surface of the leaves at the beginning of summer. The larvae are greenish yellow and reach the adult stage in about a month. Wherever the larvae occur there is a corresponding swelling of the tissue, resembling a gall, on the upper surface of the leaf. The body of the larva fits exactly into this pseudo-gall, its dorsal part lying flush with the lower surface of the leaf. *Trioza* is not a serious local pest, though it occurs sometimes in appreciable numbers. When such is the case, the attacked leaves fall off, though not until the insects have reached the adult stage.

Mandarines suffer every year from attacks of the fruit-fly, *Ceratitis catoiri*, Guér. The only remedial measure against this pest would appear to lie in the introduction of parasites.

Mango.

Batocera rubus, L. The larva of this Longicorn beetle causes appreciable damage to various trees, amongst which is the mango. In certain cases trees have been found to suffer so severely that control measures had to be adopted.

Eight to ten years ago a Cecidomyiid fly, *Procontarinia matteiana*, Kieff., found its way into the Colony. It is known to occur also in India, and was probably introduced accidentally from that country. The insect is extremely destructive, and wherever it is found the yield is reduced enormously, the leaves being infested when they are still quite tender and about 2 inches long (fig. 1). At this stage small spots

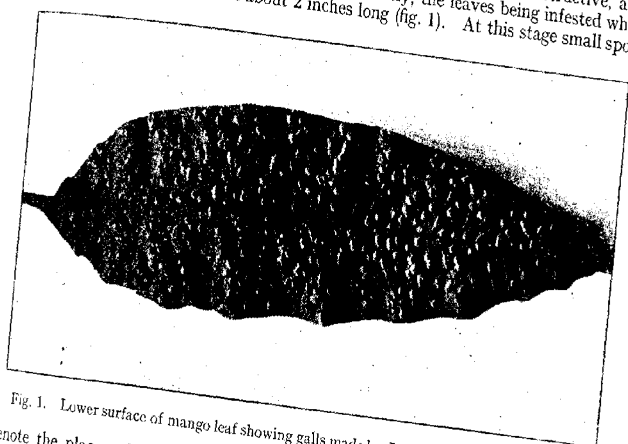


Fig. 1. Lower surface of mango leaf showing galls made by *Procontarinia matteiana*, Kieff.,

denote the places where the insect has oviposited. As the larva grows up in the leaf tissue, a gall is formed; the one harbouring the adult insect prior to its emergence measures from 1·5 to 2·0 mm. in diameter. The gall shows equally on either surface of the leaf, but the fly emerges by puncturing the lower surface. Infestation is usually very severe, as many as 150 to 300 galls being formed on a single leaf. They occur in such large numbers that they touch one another, there being scarcely room for more. The leaves affected in this way soon dry and fall off. The life-cycle of the insect is about two months, its period of most common occurrence being from November to June inclusive.

Coccus mangiferae, Green, is quite common and sometimes occurs in great numbers. After the Cecidomyiid, it certainly is the worst pest of the mango leaf. The other undermentioned COCCIDAE cannot as a rule be regarded as regular pests. These are:—*Coccus hesperidum*, L., *Eucalymnatus tessellatus*, Sign., *Chionaspis dilatata*, Green, *Pseudaonidia trilobitiformis*, Green, *Vinsonia stellifera*, Westw., and *Icerya seychellarum*, Westw. The last-named is sometimes quite common and does a certain amount of injury. As a result of the combined attacks of scale-insects, the leaves become covered with their honey secretions. On this covering there is a dense growth of sooty mould (*Capnodium* sp.), which obstructs the stomata. The leaves have a miserable appearance and cannot carry on their physiological functions as they should, so that the whole tree suffers.

The larva of the mango weevil, *Cryptorrhynchus mangiferae*, F., feeds in the stone, where it pupates. It is not a seriously destructive pest.

Ceratitis catoiri, Guér. A certain amount of damage is caused by the larva of this fruit-fly.

Peaches.

Adoretus versutus is more or less common all over the island, and frequently attacks the leaves.

Aulacaspis pentagona, Targ., occurs on the stems and twigs. In the hot coastal regions this pest is the worst of those affecting this plant. It is extremely common and causes the death of a great number of trees every year.

Cydia pomonella, L., is another regular pest and is most harmful to peaches. On an average 75 per cent. of the fruits are infested, especially at the beginning of the ripening season.

Banana.

Bananas are grown all over the island, and many varieties are cultivated, amongst them being the "Nain" and "Ollier." The "Gingeli" is affected with a disease of the fruit in the colder districts, but the other varieties thrive all over the country and form one of the chief food-stuffs of the poorer classes. They constitute the most popular fruit of the island, as they are cheap and procurable during most of the year.

The black banana weevil, *Cosmopolites sordidus*, Germ., is the only pest. The larvae live in the root-stock and occur sometimes in such great numbers as to cause the death of the plant. The varieties known as "Gingeli" and "Banane Carrée" are particularly affected.

THE EGG PARASITES OF THE COFFEE BUG (*ANTESTIA LINEATICOLLIS*, STAL) IN KENYA COLONY.

By F. W. Dry, M.Sc.,

Recently Assistant Government Entomologist, Kenya Colony.

I. Introduction.

Some account of work on the egg-parasites of the coffee bug in Kenya Colony has already been published in a bulletin of the Department of Agriculture of that country.*

When that bulletin was written the two common species of egg-parasites had not been identified, and they were consequently referred to simply as "Species A, Brown Parasite," and "Species B, Black Parasite." These two species both proved to be new and have since been described by Dodd,† "A" as *Hadronotus antestiae*, and "B" as *Telenomus truncativentris*. They may be roughly distinguished as follows:—

Hadronotus. Abdomen brown, head and thorax black in the female; head, thorax, and abdomen black in the male; black colour dull; antennae in both sexes of 13 segments.

Telenomus. Head, thorax, and abdomen bright glossy black in both sexes; abdomen of a different type from that of *Hadronotus*; antenna of the female 12-segmented and comparatively short and clubbed, antenna of the male 13-segmented, comparatively long and moniliform.

It is now possible to give some additional facts, but it should be made clear that the investigation is in a very incomplete state. This account, put together upon the present writer's ceasing to work in Kenya Colony, is a short summary of what has so far been ascertained.

II. The Life-history of the Coffee Bug.

A full account of the life-history of the coffee bug is given by Mr. Anderson. The following facts, the chief ones about the life-cycle that have a bearing on the relation between the bug and its egg-parasites, are taken from his bulletin.

The egg stage and all the instars of the nymphal stage were passed through considerably faster in hot than in cool weather. The length of the egg stage varied from about 9 days in the hotter months to about 13 days in the cooler ones. The average length of the nymphal stage was, for the hotter months, about 75 days, for the colder, 115 days. Combining egg and nymphal periods, the average times from egg-laying to the nymph becoming adult were respectively 84 days and 128 days. The average adult life for both sexes was a little over 100 days, but the length of life was frequently much longer, the maximum found for a female being 290 days, that for a male 249 days. The average number of eggs laid during the lifetime of a female was 126, but the number was often very much more, 485 being the highest obtained.

The egg of the coffee bug, as Mr. Anderson describes it, "is dull white in colour, covered with a fine powder which easily rubs off, leaving the egg clear and glistening. This powder appears in the form of a delicate reticulation. The egg measures roughly $\frac{3}{4}$ mm. by 1 mm. The measurement of 100 eggs, taken at random, gave

* Anderson, T. J.—The Coffee Bug.—B.E.A. Dept. of Agric., Div. of Ent., Bull. i, 1919.

† Dodd, A. P. Notes on the Exotic Proctotrupoidea in the British and Oxford University Museums.—Trans. Ent. Soc. Lond., Jan. 1920.

the following averages :—shorter axis 0·87 mm., longer axis 1·125 mm., the longer axis being at right angles to the point of attachment. As the embryo develops within the egg a clear ring becomes distinct on the top, marking the place where the cap will split off when the young nymph emerges. The cap is a complete arc of the egg-shell and may be completely split off or left behind, hinged on, and may shut down accurately. In some instances it fits down so tightly that only the colour shows whether the nymphs have hatched. When the egg is from four days to a week old, depending on the season, the eyes and tylus of the nymph can be distinguished as darker spots shining through the cap. The eggs are usually found in clumps of twelve, though ten and eleven are quite common. The clumps of eggs are found on the under surfaces of the leaves, occasionally on the upper surface, on the berries, on the pedicels of the berries, on the stem, on dry leaves, and even on stones beneath the bushes." In the field 90 per cent. of the eggs collected were found on the lower side of the leaves.

III. Parasitised Eggs.

The female parasites have been watched vigorously prodding the coffee bug eggs with their ovipositors. The insect remains quiet for some time with the ovipositor embedded in the egg, the whole operation lasting from two to five minutes. Eggs that have been parasitised are distinguished by the fact that some time after being attacked by the parasite, this time varying with the season, the colour of the egg changes from the original dull white. Usually the eggs become bluish grey, but occasionally parasites emerge from eggs which have only become pale grey.

The parasite makes its way out of the egg through a hole with a ragged edge bitten by the insect's mandibles; the cap of a parasitised egg does not split off. Many hundreds of eggs have been kept singly in tubes in the laboratory, but never more than one parasite has been reared from one egg.

In addition to the two named species of parasites other species have been reared, but their numbers have been very few.

In collections brought in from the field the eggs were kept under observation so as to determine how many produced *Antestia*, how many had been parasitised, and how many failed both to turn blue and to produce either bug or parasite. All eggs which turned blue were recorded as parasitised, and were then kept in tubes plugged with pads of cotton wool. The parasites hatching from them were preserved and examined, and data for proportions of species and sexes are given below. Some of the eggs which turned blue did not produce parasites. Any eggs about which there was a doubt were kept until they produced parasites or until it was clear that they were not going to produce anything.

In making counts it was the practice to reject all eggs which had hatched—whether *Antestia* or parasites—before being collected, and to reject as well all clumps containing one or more eggs which had hatched before coming to hand. In this way, for each collection of eggs examined, percentages were obtained of those hatching *Antestia*, those parasitised, and those not going blue or hatching anything. The figures so calculated may be taken to represent fairly well the parasite position in the plantations where the collections were made, but the following sources of inaccuracy must be noted :—

(*a*) A parasitised egg remains unhatched longer than one which produces a coffee bug.

(*b*) If the eggs had not been brought into the laboratory some which hatched *Antestia* would have been parasitised in the field; this tends to counterbalance (*a*).

(*c*) Dead eggs, white or blue, remain on the trees a long time.

In discussing the data from collections of eggs we may conveniently divide these collections into two lots :—

A. Those from a field of coffee about six acres in extent on the Government Farm at Kabete. From this field a considerable number of collections have been made over a period of two and a half years. Particulars from these collections will be given first.

B. Those from various other coffee plantations in the districts of Nairobi, Kyambu, Limuru and Thika, but on these plantations usually only a single collection has been made, and that generally at the time of an *Antestia* outbreak. It will not be necessary to say much about the data from these occasional collections.

IV. Collections from Government Farm, Kabete.

Between July 1917 and September 1920 twenty-four collections were made from this field in as many different months. The eggs collected totalled 16,531, and the months in which they were obtained are shown in Table I.

The chief points brought to light are the following :—

The average of the monthly percentages of eggs producing *Antestia* was 15 per cent.; several times the percentage was 30 or over, while, on the other hand, of more than 5,000 eggs collected between July and October 1917 only 5 per cent. produced *Antestia*. Of the 16,531 eggs collected during the period indicated, 12,882, or 78 per cent., were parasitised, the average of the monthly percentages being practically the same as this figure, namely, 77 per cent.; the lowest monthly percentage was 54 per cent., the highest more than 90 per cent. The average monthly percentage of eggs which did not go blue and did not hatch was 8 per cent., and of those eggs which did go blue 24 per cent. did not produce parasites. Of coffee bug eggs laid in the laboratory and protected from parasites a small proportion did not hatch. Some eggs, too, exposed to parasites in the laboratory turned blue but did not produce parasites.

The causes of eggs not hatching have not been inquired into. Superparasitism and hyperparasitism, which may quite likely be connected with the failure of parasitised eggs to produce parasites, have not been investigated.

In the 9,750 parasites that were reared, the proportions of the sexes of the two species were as follows :—

	♂♂	%♂♂	♀♀	%♀♀	Total.
Hadronotus	1168	22·6	4009	77·4	5177
Telenomus	1079	23·6	3494	76·4	4573

For both species, therefore, the proportion of females to males was a little greater than 3 to 1. Figures from smaller collections from other plantations also point to a ratio of 3 or 4 to 1.

The total numbers of the two species have just been given. These give as percentages for the two species :—*Hadronotus*, 53 per cent.; *Telenomus*, 47 per cent. But it must be noted that at those periods when coffee bug eggs were most numerous *Hadronotus* usually considerably outnumbered *Telenomus*. So that, if we take the average of the quarterly percentages (*see* Table I) we then get :—*Hadronotus*, 43 per cent.; *Telenomus*, 57 per cent. Both these pairs of figures, however, indicate that, over a long period, the numbers of the two species in this Kabete field were fairly evenly balanced.

The variations in the frequency of the two species, for quarterly periods, are shown in Table I (p. 200). We may note :—

1. The variations are considerable; sometimes 70 per cent. or 80 per cent. were *Hadronotus*, sometimes 80 per cent. or 90 per cent. were *Telenomus*.

2. So far as the data go, the periods of ascendency of either species lasted for from six to nine months. This time is sufficient, as the life-history figures will show, for from four to six successive generations of parasites.

3. Ascendency of *Hadronotus* is associated with comparative abundance of coffee bug eggs. Though an accurate index of the comparative abundance of eggs was not obtained, it can be stated that they were most numerous from July to October 1917, and the period of next greatest abundance was October 1918 to March 1919. At the end of 1917 and for the first three months of 1918 they were very scarce indeed. During the remainder of the time they were moderately plentiful, though not very numerous.

V. Collections from other Plantations.

The data as yet obtained are far too few for us to be able to correlate the occurrence and subsidence of outbreaks of *Antestia* with parasite conditions, but the following points may be mentioned :—

In collections of eggs made during outbreaks of *Antestia* the percentages of normal eggs have sometimes been high and the percentages of parasitised eggs low. The following are examples :—

	Place.	Date.	Total number eggs.	Percentage producing *Antestia*.	Percentage parasitised.	Percentage not going blue and not producing anything.
1.	Near Nairobi ..	March 1918 ..	640	52	46	2
2.	Limuru	May 1918	1008	58	37	5
3.	Limuru	May 1920	1327	34	63	3

On the other hand, collections of eggs made during an outbreak of *Antestia* have sometimes given a low percentage of normal eggs and a high one of parasitised eggs. Such cases are :—

	Place.	Date.	Total number eggs.	Percentage producing *Antestia*.	Percentage parasitised.	Percentage not going blue and not producing anything.
4.	Kyambu	August 1917 ..	1500	6	85	9
5.	Kyambu	Sept. 1918 ..	637	7	84	9
6.	Kyambu	January 1920 ..	1191	3	87	10

The Kyambu case numbered (4) is an example of an outbreak of *Antestia* subsiding without any control measures having been taken by the planter. At the time the collection was made the bugs were extremely numerous in part of the plantation. In such cases it is usual to have the bugs collected by hand, but here, although they were left undisturbed, the following April the planter reported that the outbreak had completely subsided. This was probably due to the work of the parasites.

The Kabete field in 1917 may also be cited. In June and July the bugs were quite plentiful. In the months July to October 1917, as has already been stated

only 5 per cent. of the eggs collected produced *Antestia*, more than 85 per cent. being parasitised. Since then—up to the end of 1920—the bugs have never been at all plentiful there.

The parasites are sometimes present in force in plantations where there has never been a coffee bug outbreak. The following figures are for a field of coffee about three years old, when the collection of eggs was made where there had never been an outbreak :—

	Place.	Date.	Total number eggs.	Percentage producing *Antestia*.	Percentage parasitised.	Percentage not going blue and not producing anything.
7.	Near Nairobi ..	Sept. 1918 ..	862	4	86	10

The usual state of affairs in coffee plantations, it may here be remarked, is that *Antestia* exists in small numbers only, but if the bug was present in a plantation, parasitised eggs have always been found when a search has been made for them.

There are several cases on record when one outbreak of *Antestia* that has been controlled by collecting the bugs by hand has been followed by another after some such period as two years.

From some collections, notably from the Limuru district, *Hadronotus* has been completely absent, though a very small number of *Hadronotus* have been reared from eggs from one Limuru plantation. *Telenomus* has been reared from every collection examined.

VI. Life-history Work on the Parasites.

Many of the facts here given have already been published in Mr. Anderson's bulletin.

A. Hadronotus antestiae.

(1) *Length of Life of Parasites.*

For parasites kept in tubes closed with a pad of dry cotton-wool, provided with water on a pad of cotton-wool moistened daily, and with coffee bug eggs in the tube, the average length of life for either sex was about six days.

Five unmated females kept singly in tubes, provided daily with diluted golden syrup on a pad of cotton-wool and supplied with coffee bug eggs, lived on the average 13 days. Further data for parasites which did not have access to coffee bug eggs have given a slightly shorter time. The longest life of a female recorded is 16 days, that of a male 13 days.

(2) *Life-cycle of Parasites ; Mated Females given Water only.*

A series of experiments, in which the conditions defined below were adhered to, was designed to compare the reproductive powers of the two species. The facts for *Telenomus* will be given when the life-cycle work on that species is described.

The conditions were as follows :—(*a*) The experiment was set going not earlier than 22.xi.17 and not later than 21.ii.18 ; (*b*) all parasites used as parents had emerged from the coffee bug egg on the day on which the experiment was started ; (*c*) all the parasites used were known to be virgin, as they had emerged in tubes not containing any individuals of the opposite sex ; (*d*) the act of copulation was observed to take place ; (*e*) once a parasite, male or female, had mated, no individual except its mate was allowed access to it during the remainder of its life ; (*f*) the parasites were given

no food, but a pad of cotton-wool was kept moist in the glass tube, which was closed with a dry pad of cotton-wool; (*g*) the *Antestia* eggs used had been deposited in the laboratory, and so kept as to prevent their accidental parasitisation; (*h*) none of the eggs showed eye-spots when given to the parasites; (*i*) the number of eggs in each experiment was 50; when the experiment started eggs to this number were placed in a little cork tray having a rough floor so that the eggs would not roll about.

The results obtained from a series of ten experiments in which the above conditions were observed were as follows:—

(*a*) The average lifetime of the parent parasites was 6 days, 8 days being the maximum.

(*b*) On the average a little longer than 10 days elapsed before the first egg became blue, and between 13 and 14 days before the last one to become blue had changed; it will thus be noticed that the time from parasitisation of the egg to its going blue was about a third of the time from parasitisation to emergence of the parasite.

(*c*) The average time between the mating of the parasites and the first hatching of their progeny was 31 days.

(*d*) The total number of offspring obtained from the ten females was 233, or an average of a little over 23 per female; 256 eggs went blue, but 23 did not produce parasites; the highest number of offspring from one female was 34.

(*e*) Of the 233 parasites thus obtained the numbers of the sexes were:—Male, 43; female, 190.

(3) *Proportions of the Sexes.*

At the same time as the series just described other experiments with mated females, not fed but given water, were carried out in which one or more of the conditions were not the same as those defined above. Particulars of some of these will be given directly. The times obtained were not dissimilar from those just recorded, and need not be given, but these other experiments give a larger number of parasites reared in the laboratory from mated parents from which to calculate the proportions of the sexes.

In 41 experiments, including the ten of the series just described, the numbers of the sexes were:—Male, 178; female, 696. The percentages were thus almost exactly:—Male, 20 per cent.; female, 80 per cent.

In every one of these 41 experiments the number of females exceeded the number of males. In one experiment only all the offspring, 34 in number, were female. In that experiment the parent male was the offspring of a virgin female. In six other experiments in which the parent males were bred from virgin mothers the offspring, totalling 31 males and 89 females, always included both sexes.

(4) *One Male mating with several Females.*

It was found that males will readily mate with several females. Mating, for both species of parasites, is an affair of seconds. Occasionally a male would mate twice with one female in rapid succession, but very often, and this applies also to *Telenomus*, I noticed that a female which had been mated would run away from or resist further attentions from the male.

One *Hadronotus* male, which emerged from a coffee bug egg on 30.xii.1917 and was never given food or drink, and died on 4.i.1918, mated during the course of his life with 16 virgin females. These 16 were all that were available; with the first two he mated twice, with the others once. These females were kept away from all other males for the remainder of their lives, being kept singly in tubes, provided with water, and supplied with eggs; 369 parasites were in all bred from them, 68 male, and 301 female. In every instance the number of females exceeded the number of males.

This experiment, it may be remarked, gives us the evidence of 14 cases that a single mating sufficed to produce a similar proportion of females to that found in parasites reared from eggs from the field.

(5) *Parthenogenetic Reproduction.*

In a series of 20 experiments females to which no male had ever had access were given coffee bug eggs. All the conditions defined for the series of ten mated pairs, other than those relating to mating, were observed, and the times of the life-cycle were not different from those obtained in that series. From these 20 females 442 offspring were obtained, all males; 482 eggs went blue, but 40 did not produce parasites. The largest number from one female was 40. In other experiments described under (6) and (7), in some of which the parent parasites were fed and the number of offspring was larger, all the parasites reared were males. In no single case under observation has a female been produced parthenogenetically.

(6) *Parasitisation of Eye-spotted Eggs.*

In two experiments with unmated females all the conditions of the series described above under (2) were fulfilled except one (*h*)—for all the 50 eggs, which had been laid in the laboratory and protected from parasites, showed eye-spots when they were given to the parasites. In these two experiments 28 parasites were bred, thus showing that eye-spotted eggs can be parasitised. Just how late such eggs can be successfully attacked by the parasites has not been determined.

When eggs are parasitised which do not show eye-spots, the change of colour from white to blue is fairly sudden. Often on one day such an egg will be of the typical white colour, and on the next of the typical blue. But when eye-spotted eggs are parasitised the change of colour is more gradual. After a few days—a shorter time than that in which eggs not eye-spotted would require to go blue—the colour becomes a dirty brown, which deepens with successive days. In these two experiments the eye-spots gradually faded and eventually could not be distinguished. The eggs then took on the typical blue colour, but it was not so easy as with eggs not eye-spotted to say exactly when the change took place.

(7) *Number of Eggs parasitised by fed Females, unmated.*

In each of five experiments one unmated female was given thirty different *Antestia* eggs every three days. The average number of offspring parasites, all males, obtained in these experiments was 51, the maximum being 83. These numbers are considerably higher than those obtained under the conditions of the experiments described above.

(8) *Variations in the Length of the Life-cycle.*

In hot weather the life-cycle is passed through more quickly than when it is cooler. Particulars are given in Table II (p. 201) of a series of experiments in which *Antestia* eggs, laid in the laboratory and protected from parasitisation, were placed for a short time in a tube containing numerous parasites. The minimum times for the life-cycle in the different experiments varied from 25 to 62 days. For meteorological data, see Table IV (p. 201).

It will be noticed that the time elapsing before the eggs go blue is always about a third of the period of the parasite's life-cycle within the egg.

B. **Telenomus truncativentris.**

The facts obtained in life-history work on *Telenomus* will be discussed in much the same order as for *Hadronotus*. Unless stated otherwise, the conditions in corresponding experiments on the two species were the same.

(1) *Length of Life of Parasites.*

The average length of life, for both males and females, was about 4 days when they were given water only. When fed on diluted golden syrup the average length

of life of unmated females provided with *Antestia* eggs was 22 days. Further data for fed parasites of both sexes, some with access to *Antestia* eggs, some without, have given a slightly less time. The greatest length of life of a female—one of those provided with eggs—was 51 days, that of a male 16 days.

(2) *Life-cycle of Parasites; Mated Females given Water only.*

The results of a series of ten experiments corresponding to those described for *Hadronotus* under A (2) were :—

(*a*) The average lifetime of the parent parasites, as already stated, was about 4 days, 6 days being the maximum.

(*b*) The first egg became blue after an average of 9 days, the last one after an average of 11 days.

(*c*) As with *Hadronotus*, the time from parasitisation of the egg to its going blue was about a third of the length of the development within the coffee bug egg.

(*d*) The average time between the mating of the parasites and the first hatching of their progeny was between 27 and 28 days.

(*e*) The total number of offspring obtained from ten females was 75, or 7½ per female ; 89 eggs went blue, but 14 did not produce parasites. The highest number of offspring was 12.

(*f*) Of the 75 parasites thus obtained the numbers of the sexes were :—Male, 46 ; female, 29.

(3) *Proportion of the Sexes.*

In the series of experiments of which the results have just been given considerably more males were bred than females.

Like *Hadronotus*, *Telenomus* can reproduce parthenogenetically, all the offspring so produced also being males. In the experiments under discussion, however, the act of copulation was in every case watched. In eight of the experiments one or more females were produced ; in two cases all the offspring were males, numbering 2 in one and 9 in the other. Now it has been shown that from collections of eggs from the field, for *Telenomus*, as for *Hadronotus*, the proportion of females to males is about 3 or 4 to 1. This, therefore, is the proportion of the sexes we should look for in normal bisexual breeding. We therefore want to know—and this problem has not been solved yet—why the proportion of females bred in the laboratory was lower than that of females reared from eggs from the field.

A limited number of experiments with mated females fed on dilute golden syrup were carried out, and the following short series may be taken as a hint which needs to be followed up. It so happened that three females emerged from coffee bug eggs in the presence of males about a day older than themselves. After all these parasites had been together about a day they were separated into three pairs of male and female. Each pair was put in a tube, given 30 *Antestia* eggs, and provided with dilute golden syrup until death. The act of copulation was not observed. From these three females the offspring bred were :—Male, 10 ; female, 40.

(4) *One Male mating with several Females.*

Males in the laboratory have mated with two, three, or four females. In no experiments were males given the opportunity to mate with any number much larger than four.

(5) *Parthenogenetic Reproduction.*

In a series of 20 experiments with unmated females the times of the life-cycle were similar to those for mated females ; 159 parasites, all males, were bred from the 20 females ; 196 eggs went blue, but 37 did not produce parasites ; the largest number from one female was 19. In other experiments to be described under (6)

and (7), in some of which the parent parasites were fed and the number of offspring was larger, all the parasites reared were males. In no single case under observation has a female been produced parthenogenetically.

(6) *Parasitisation of Eye-spotted Eggs.*

In one experiment similar to those described under A (6) 4 male *Telenomus* were bred in eggs eye-spotted when they were offered to the parasite. The note about the change of colour of eye-spotted eggs parasitised by *Hadronotus* is applicable to those parasitised by *Telenomus.*

(7) *Number of Eggs parasitised by fed Females, unmated.*

In a series of five experiments with unmated females like those described for *Hadronotus* the average number of offspring parasites, all males, was 22, the maximum being 41. These numbers are, it will be seen, appreciably higher than those obtained when the parasites were only given water.

(8) *Variations in the Length of the Life-cycle.*

As with *Hadronotus*, the life-cycle is passed through more quickly in hotter than in cooler weather. Table III for *Telenomus* corresponds to Table II for the other species. The minimum times for the life-cycle in the different experiments varied from 46 to 21 days. Again, the eggs go blue after about a third of the period of the parasite's development within the egg has been passed through.

C. A Comparison of the Data for Hadronotus and Telenomus.

As has been shown, many of the facts recorded for the two species are similar. The chief differences to be noted are :—

1. In laboratory conditions, whether the parasites were fed on dilute golden syrup or only given water, *Hadronotus* produced more offspring than *Telenomus*.
2. In the offspring of *Hadronotus* mated in the laboratory there was an excess of females like that found in rearing parasites from the field. From mated *Telenomus* in laboratory conditions more males than females were generally bred.
3. For a given time of year *Telenomus* passes through its life-cycle rather more quickly than *Hadronotus.*
4. With hotter weather the life-cycle of *Hadronotus* is speeded up proportionately more than that of *Telenomus*. (Contrast Tables II and III. Temperature data are given in Table IV.)

VII. The Bearing of Laboratory Data on Field Data.

Much more laboratory work is needed to elucidate the facts from the field, but the following conclusions or suggestions may be put down.

1. On comparing the lengths of the life-cycles and the numbers of offspring per female of *Antestia* and *Hadronotus*, and *Antestia* and *Telenomus*, we see that both species of parasites have a quicker rate of reproduction than *Antestia*. But it must be borne in mind that the egg-laying powers of *Antestia* are considerable. The average number of eggs per female in the laboratory was 126. Nothing is known of the mortality of nymphal coffee bugs in field conditions, so it is clearly possible that when only some apparently small percentage—say 10 per cent.—of eggs are producing *Antestia*, the numbers of the bug may be well on the increase.

2. In the field, with both species of parasites, mating is the rule ; parthenogenesis is at any rate rare.

3. Not so much light as could be desired is thrown on the problem of the vicissitudes of the two species of parasites in the Kabete field. When we find two species of parasites both attacking the same host we naturally ask why one does not succeed in crowding out the other completely. As it is very unlikely that the resultant of their reactions to the same set of conditions will be precisely the same, we are disposed to look for some condition, not always constant, which affects the two differently.

Such a condition we did find when it was learnt that the life-cycle of *Hadronotus* is speeded up more in hotter weather than that of *Telenomus*. This, however, does not give us the explanation of the facts from the Kabete field. There it appears that comparative abundance of *Antestia* eggs results in the proportion of *Hadronotus* going up, while scarcity of *Antestia* eggs would seem to send the proportion down. We may make the obvious suggestion that under natural conditions, as in the laboratory, *Hadronotus* has greater reproductive powers than *Telenomus*, but that for some reason *Telenomus* is better able than *Hadronotus* to find the eggs in times of scarcity. We need, therefore, to know much more about our two species.

With regard to the effects of temperature, reference may again be made to the almost complete absence of *Hadronotus* from the several lots of parasites reared from Limuru. The Limuru district, being higher than the Kabete field, is colder, and it may be that it is this condition that gives the advantage to *Telenomus*.

VIII. Conclusion.

The facts so far ascertained have been recorded, together with some hints or suggestions, and this account will have indicated a number of points calling for further inquiry. Reference may be made to the life-history of the parasites within the coffee bug egg, to superparasitism and hyperparasitism, to the effect of laboratory conditions upon the proportions of the sexes of *Telenomus*, to the behaviour of the parasites, and to a systematic following up of the parasites in a number of plantations. These are some of the lines of work which need to be undertaken to enable us to understand the interactions between *Antestia, Hadronotus*, and *Telenomus.*

Table I.

Collections of Coffee Bug Eggs from 6-acre Field, Government Farm, Kabete.

Period.	Months during which eggs were collected.	Total number of parasites.	*Hadronotus.*		*Telenomus.*	
			No.	%	No.	%
1917.						
3rd Quarter	July, Aug., Sept.	2557	1469	57	1088	43
4th Quarter	Oct.	955	627	66	328	34
1918.						
1st Quarter	..	Eggs	very scarce.			
2nd Quarter	April, June	413	32	8	381	92
3rd Quarter	July, Aug., Sept.	771	219	28	552	72
4th Quarter	Oct., Nov., Dec.	1227	924	75	303	25
1919.						
1st Quarter	Jan., Feb., Mar.	1579	1167	74	412	26
2nd Quarter	April, May, June	488	412	84	76	16
3rd Quarter	..	Eggs	not collected.			
4th Quarter	Nov.	340	153	45	187	55
1920.						
1st Quarter	Jan.	632	104	16	528	84
2nd Quarter	May	295	35	12	260	88
3rd Quarter	July, Sept.	493	35	7	458	93
Totals		9750	5177	53	4573	47
Averages of monthly percentages		..	..	43	..	57

Table II.

Variations in the Length of the Life-cycle of Hadronotus.

Antestia eggs exposed to parasites. From.	To.	Number of days to first eggs blue.	First parasites emerged.	Number of days to first emergence.	Number of days during which emergence continued.	Total number of parasites.
11.vii.18	12.vii.18	21	11.ix.18	62	3	10
16.vii.18	17.vii.18	20	14.ix.18	60	6	18
23.vii.18	24.vii.18	19	18.ix.18	57	4	20
31.vii.18	1.viii.18	21	24.ix.18	55	7	8
4.viii.18	5.viii.18	20	24.ix.18	51	8	11
9.viii.18	10.viii.18	19	26.ix.18	48	7	8
2.ix.18	3.ix.18	13	8.x.18	36	10	18
16.ix.18	17.ix.18	10	18.x.18	32	3	30
19.ix.18	20.ix.18	10	19.x.18	30	5	30
20.xii.18	23.xii.18	8	22.i.19	33	4	23
30.i.19	2.ii.19	7	23.ii.19	24	2	28
2.ii.19	5.ii.19	7	27.ii.19	25	2	17

Particulars of the life-cycle during the months November 1917 to March 1918 are given under VI.A.

Table III.

Variations in the Length of the Life-cycle of Telenomus.

Antestia eggs exposed to parasites. From.	To.	Number of days to first eggs blue.	First parasites emerged.	Number of days to first emergence.	Number of days during which emergence continued.	Total number of parasites.
10.vii.18	11.vii.18	13	25.viii.18	46	2	13
22.vii.18	23.vii.18	13	5.ix.18	45	4	36
23.vii.18	24.vii.18	13	5.ix.18	44	5	23
27.vii.18	28.vii.18	13	8.ix.18	43	1	9
4.viii.18	5.viii.18	13	13.ix.18	40	3	21
9.viii.18	10.viii.18	14	18.ix.18	40	2	6
13.ix.18	14.ix.18	9	11.x.18	28	2	4
19.ix.18	20.ix.18	9	18.x.18	29	1	3
17.xii.18	20.xii.18	9	16.i.19	30	3	7
25.i.19	28.i.19	8	16.ii.19	22	2	8
28.i.19	31.i.19	9	18.ii.19	21	4	6
31.i.19	3.ii.19	7	22.ii.19	22	5	8

Particulars of the life-cycle during the months November 1917 to March 1918 are given under VI.B.

Table IV.

Monthly Temperature Data, Government Farm, Kabete, 1917 to 1920.

Month.	1917.			1918.			1919.			1920.		
	Average daily Minimum.	Average daily Maximum.	Combined Average daily Minimum and Average daily Maximum.	Average daily Minimum.	Average daily Maximum.	Combined Average daily Minimum and Average daily Maximum.	Average daily Minimum.	Average daily Maximum.	Combined Average daily Minimum and Average daily Maximum.	Average daily Minimum.	Average daily Maximum.	Combined Average daily Minimum and Average daily Maximum.
Jan. ..	50	72	61	46	78	62	52	77	64½	49	78	63½
Feb. ..	52	73	62½	48	79	63½	55	78	66½	49	81	65
March ..	51	75	63	49	80	64½	55	78	66½	55	72	63½
April ..	55	71	63	54	73	63½	56	74	65	56	73	64½
May ..	53	71	62	53	70	61½	54	72	63	58	61	59½
June ..	50	68	59	52	68	60	50	70	60	51	65	58
July ..	47	69	58	50	68	59	50	66	58	50	67	58½
Aug. ..	50	70	60	49	70	59½	48	72	60	49	69	59
Sept. ..	49	73	61	49	75	62	52	74	63	47	73	60
Oct. ..	52	74	63	54	77	65½	54	72	63	52	73	62½
Nov. ..	51	73	62	53	73	63	52	73	62½	55	71	63
Dec. ..	46	77	61½	53	73	63	49	75	62	53	70	61½

COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st April and 30th June 1921, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Mr. E. BALLARD, Government Entomologist :—60 Rhynchota ; from South India.

Mr. H. A. BALLOU, Entomologist, Imperial Department of Agriculture :—11 Weevils and 8 early stages ; from Grenada.

Mr. C. F. C. BEESON, Forest Zoologist :—252 Coleoptera ; from India.

Mr. G. E. BODKIN, Government Economic Biologist :—13 Culicidae, 5 Hippoboscidae, 4 Siphonaptera, 2 Hymenoptera, 33 Coleoptera, 1 species of Coccidae, 10 other Rhynchota, 3 Orthoptera, 2 Mantispids, 5 Odonata, and 15 Mallophaga ; from British Guiana.

Mr. JOHN R. BOVELL, Superintendent of Agriculture :—1 Culicid, 4 other Diptera, 8 Chalcididae, 5 Coleoptera, 6 Lepidoptera, 37 Isoptera, 2 species of Coccidae, 4 Aphididae, and 1 Pentatomid bug ; from Barbados.

Prof. C. K. BRAIN :—34 Coleoptera, 2 Trichoptera, 7 Planipennia, and 7 Odonata ; from South Africa.

Major-General Sir DAVID BRUCE, K.C.B., F.R.S. :—100 Ants and 2 Weevils ; from Madeira.

Mr. P. A. BUXTON :—10 Culicidae, 27 Tabanidae, 5 *Stomoxys*, 95 other Diptera, 1 Dipterous pupa case, 1 Vespid, 107 Coleoptera, 4 Lepidoptera, 1 species of Coccidae, 19 other Rhynchota, 64 Orthoptera and 1 Dragon-fly ; from Palestine.

Director of Agriculture, Baghdad :—150 Hymenoptera, 7 Coleoptera, 50 Thysanoptera, 4 species of Aleurodidae, 5 Orthoptera, and 100 Mites ; from Mesopotamia.

Director of Agriculture, N. Nigeria :—19 Hymenoptera and 7 Moths ; from West Africa.

Division of Entomology, Pretoria :—40 Coleoptera, 2 Lepidoptera, 1 Tingidid, and 451 Orthoptera ; from South Africa.

Dr. H. LYNDHURST DUKE :—225 Isoptera, 1 Worm attacking *Glossina*, and 1 tube of Fungi ; from Uganda.

Mr. J. C. FAURE :—4 Rhynchota and 213 Orthoptera ; from South Africa.

Mr. T. BAINBRIGGE FLETCHER, Imperial Entomologist :—99 species of Coccidae ; from India.

Mr. C. C. GOWDEY, Government Entomologist :—2 Diptera, 23 Hymenoptera, 19 Coleoptera, 19 Lepidoptera, 30 Isoptera, 35 Thysanoptera, 8 species of Coccidae, a number of Aphididae, 11 other Rhynchota, 2 Orthoptera, and 13 Ticks ; from Jamaica.

Mr. C. B. HARDENBERG, Chief Entomologist, Department of Agriculture :—204 Coleoptera ; from Portuguese East Africa.

Mr. H. HARGREAVES, Government Entomologist :—34 Diptera, 41 Hymenoptera, 96 Coleoptera, 21 Lepidoptera, 2 species of Coccidae, 22 other Rhynchota, 6 Orthoptera, 14 Spiders, 3 Centipedes, 15 Crustacea, 9 Millipedes, and 20 Mollusca ; from Uganda.

Mr. G. F. HILL, Entomologist, Australian Institute of Tropical Medicine :—124 Culicidae, 52 Tabanidae, 5 Hymenoptera, 31 Coleoptera, 27 Lepidoptera, 9 Isoptera, 2 species of Coccidae, 13 other Rhynchota and 2 Orthoptera ; from Australia.

Mr. M. AFZAL HUSAIN, Government Entomologist :—151 Parasitic Hymenoptera and 19 Jassids ; from the Punjab.

Mr. J. C. HUTSON :—230 Thysanoptera ; from Ceylon.

Mr. R. W. JACK, Chief Entomologist, Department of Agriculture, Rhodesia :—3 Coleoptera ; from South Africa.

Dr. W. A. LAMBORN :—4,368 Culicidae, 1 *Haematopota*, 27 other Diptera, 772 Hymenoptera, 2 Coleoptera, 3 Lepidoptera, 9 Lepidopterous puparia parasitised by Chalcids ; from the Federated Malay States.

Dr. LL. LLOYD :—2 Dipterous larvae from human intestine, 2 Coleoptera, 3 Lepidoptera, 15 Thysanoptera, 2 tubes containing *Tetranychus*, and 20 Mites ; from Cheshunt, Hertfordshire.

Major W. F. M. LOUGHNAN, R.A.M.C. :—200 Ceratopogoninae ; from British Honduras.

Mr. N. C. E. MILLER :—1 species of Coccidae ; from Tanganyika Territory.

Prof. S. A. MOKRZHETSKI :—7 Coleoptera (pests of roses) ; from Bulgaria.

Mr. J. C. MOULTON :—1 Celyphid fly, 11 Coleoptera, and 1 Pentatomid bug ; from Singapore.

Mr. A. W. J. POMEROY, Government Entomologist :—244 Diptera, 282 Hymenoptera, 316 Coleoptera, 59 Lepidoptera, 118 Rhynchota, and 9 Orthoptera ; from Nigeria.

Rhodesia Museum :—175 Diptera, 150 Coleoptera, 14 Thysanoptera, 9 Rhynchota, 2 Mantispids, and 1 Chrysopa ; from South Africa.

Mr. L. E. ROBINSON :—4 Scolytidae and their borings ; from Colombia.

Senhor A. F. DE SEABRA :—1 Hippoboscid, 100 other Diptera, 14 Hymenoptera, 117 Coleoptera, 40 Rhynchota, 2 Orthoptera, and 1 Spider ; from San Thomé.

Mr. H. W. SIMMONDS :—30 Diptera, 6 Hymenoptera, 3 Coleoptera, 8 Rhynchota and 2 Chrysopa ; from Fiji.

Dr. R. VAN SOMEREN :—1 Tipulid, 3 Hymenoptera, and 2 species of Coccidae ; from Kenya Colony.

Mr. R. SWAINSON-HALL, F.L.S. :—5 Coleoptera, from the Island of Principe ; 23 Coleoptera, from San Thomé ; 26 Coleoptera and 11 early stages, from Portuguese Congo.

Mr. F. W. URICH :—12 Siphonaptera, 2 Hymenoptera, 70 Ticks, and 2 tubes containing Mites ; from Trinidad.

Mr. ROBERT VEITCH :—124 Coleoptera and 5 Hymenoptera ; from Fiji.

THE INFLUENCE OF DROUGHT UPON MOSQUITO LIFE IN SURREY.

By Malcolm E. MacGregor,

Wellcome Bureau of Scientific Research
(Wellcome Field Laboratory, Wisley, Surrey).

The unusual and prolonged drought that we have experienced this year has had a marked effect upon the mosquitos. So much so, that while last year I found no difficulty in obtaining any of the eleven species which so far have been found to exist in this locality, yet for many weeks now it has been impossible to obtain any but a few *Anopheles maculipennis* (adults), *Anopheles bifurcatus* (larvae), *Culicella morsitans* (larvae, pupae, and adults), and *Culex pipiens* (larvae, pupae and adults).

As I have been anxious to get specimens of the other species, which were common around here last year, in order to continue certain observations, I have made prolonged searches for them in the usual breeding-places, only to find that with most of the water collections dried up none of the species required was obtainable.

Anopheles bifurcatus.

Normal conditions.—As larvae and pupae; plentiful in slowly moving streams throughout the year. As adults; fairly numerous in pigsties from end of March to June, but unobtainable later.

Conditions during drought.—As larvae and pupae; unobtainable, except in an abnormal breeding-place (well). As adults; unobtainable since late in June.

Last year I found that large numbers of *Anopheles bifurcatus* larvae were to be found in a certain stream at Ockham throughout the summer and winter of 1920 and until the streams dried up in June of this year. The only permanent water in the vicinity was a small lake in which no Anopheline larvae were discovered last year.

I thought it probable that the *Anopheles bifurcatus* females after the stream had dried up would be forced to oviposit on the water of this lake, but repeated search has failed to discover larvae in the lake even under the present conditions of water shortage.

Soon after, having made an extensive search for Anopheline larvae along the banks on all sides of the lake, I came across a disused well in an open field near-by. Its top was covered by a loosely fitting lid, and the water in the well was about five feet deep, standing at about ten feet below the well-mouth. When examined, the water was found to be crowded with the larvae of *Culicella morsitans*, associated with which were numerous larvae of *Anopheles bifurcatus* in all stages of growth. Such an unusual situation for *Anopheles bifurcatus* larvae, moreover in water that was turbid and foul, is surely an outcome of the scarcity of water and the loss of normal breeding-places. It is nevertheless difficult to account for the females' choice of this situation instead of the water of the lake, around whose weed-protected bays the eggs might be laid in security against attack by fish. Under normal conditions, *Anopheles bifurcatus* chooses water that is clear and cool on which to lay her eggs.

The well, however, is the only situation where *Anopheles bifurcatus* larvae have been found, and the proportion of adults of this species which can be emerging at present must be infinitesimal compared with the normal.

(4183) P8/170 1000 9/21 Harrow G 75

Anopheles maculipennis.

Normal conditions.—As larvae and pupae; plentiful in farm ponds and small lakes from end of March until October. As adults; very numerous in pigsties throughout the spring and summer months. Hibernating females common during the winter months.

Conditions during drought.—As larvae and pupae; numbers relatively reduced owing to drying up of many normal breeding-places; but in certain permanent small lakes, actual numbers of larvae and pupae increased, probably on account of the scarcity of available breeding-places. As adults; plentiful but not actually numerous in pigsties.

It appears from my observations locally that *Anopheles maculipennis* is the species least affected by the drought. It chooses as a favourite breeding-place the shores of large and small natural ponds and lakes which are, of course, the last waters to dry up in conditions of drought; and this species is consequently one of the last to experience difficulty in obtaining breeding-places.

I should mention that pigsties in this locality have been found to be the favourite haunts of adult *Anopheles maculipennis* and *Anopheles bifurcatus*, and that these mosquitos are rarely found in stables. This state of affairs, which is so very different from that in other parts of the country, is, I think, due entirely to the fact that all the stables which I have visited in this county are ventilated at the junction of the wall and roof. This method ensures a very thorough ventilation, and the average temperature in the stables is much lower than the average temperature in stables where ventilation is afforded by a few windows. Furthermore, because of the architecture, the amount of light in the average stable in Surrey is much greater than that found in the average stable in Kent for instance, where Anophelines frequent the stables in large numbers. This is a matter of such significance that attention should be drawn to the value of the design in providing an " all-the-way-round " ventilation between the walls and roof, as preventing the accumulation of mosquitos in stables.

The local pigsties, on the other hand, are low-built and the contained atmosphere is close and warm at all times of the year, so that very favourable conditions are maintained for the accumulation of mosquitos when they seek a blood meal, and also conditions favourable to the hibernating females during the winter.

Anopheles plumbeus.

Normal conditions.—As larvae and pupae; found in almost every water-containing tree-hole in a variety of different kinds of trees throughout the summer and winter months. As adults; seldom observed, but occasionally in association with *Ochlerotatus* spp. they have shyly attacked me while I have remained quietly seated in the woods.

Conditions during drought.—As larvae and pupae; unobtainable now for many weeks (last captured about middle of May), as all water in tree-holes has completely evaporated. As adults; none observed since middle of May.

Anopheles plumbeus in this locality is quite common as larvae in water-containing tree-holes and, as usual, is often associated with the larvae of *Finlaya geniculata*.

Very few adults have been observed, and the one or two that I have caught sight of have eluded capture. I have been anxious to obtain adult females for some time, so as to get ova for the completion of certain observations. It occurred to me that possibly another way of obtaining ova would be carefully to clear of detritus one of the tree-holes in which *Anopheles plumbeus* had been breeding, and to keep it filled with water artifically. Unfortunately this plan did not succeed, as such hosts of insects regarded it as a providential water-supply when water was difficult to obtain that the entrance to the hole was constantly choked with a seething mass of thirsty insects.

Culex pipiens.

Normal conditions.—As larvae and pupae; abundant principally in water-troughs, rain-water barrels and other artificial water collections. As adults; abundant in houses, cellars, stables, etc.

Conditions during drought.—As larvae and pupae; relative numbers reduced, but actual numbers in available breeding-places often increased. As adults; easily found in considerable numbers, but not so numerous as in normal years.

Culex pipiens being a species that largely makes use of artificial water collections used by man, it follows that often these collections are maintained by him in spite of dry weather, and thus *Culex pipiens* is not at so great a loss to find breeding-grounds as are the less domestic mosquitos.

Culicella morsitans.

Natural conditions.—As larvae and pupae; commonly found in certain wayside ditches and in rain-water barrels. As adults; quite common in out-houses, stables, cellars and outside latrines, but never found in large numbers at a time.

Conditions during drought.—As larvae and pupae; scarce and now only found in one rain barrel kept supplied with water artificially, and in one instance found in a shallow well ten feet below ground. As adults; none observed for many weeks.

Culicella fumipennis.

Normal conditions.—As larvae and pupae; common in certain wayside ditches. As adults; frequently found on the walls in out-houses and stables.

Conditions during drought.—As larvae and pupae; unobtainable. As adults; unobtainable.

Finlaya geniculata.

Normal conditions.—As larvae and pupae; abundant in the water-containing holes in a variety of trees. Often associated with the larvae and pupae of *Anopheles plumbeus.* As adults; sometimes observed to attack human beings while they are in the woods, though not very often seen.

Conditions during drought.—As larvae and pupae; unobtainable since middle of June. As adults; unobtainable, and not observed in the woods since beginning of June.

Soon after the tree-holes had begun to dry up generally, numerous larvae and pupae of *Finlaya geniculata* were collected from several holes that still contained water, and these were brought to the laboratory for experiments on their development in waters giving different reactions. Many were placed under conditions that highly favoured development and emerged as large and active mosquitos. They were at first kept in a cage in the laboratory and fed upon dates and human blood in an attempt to obtain ova from them, but while all the females partook of an ample diet, fertilisation apparently would not take place under caged conditions, even when there were about an equal number of active and healthy males in association. In the hope of getting ova from them under natural conditions, the whole batch of mosquitos was carefully captured in tubes and taken to the vicinity of a beech-tree in which the tree-holes were kept full of water, and there released. Possibly on account of the fact that the water in the holes was besieged by insects of all kinds (see under *Anopheles plumbeus*), no eggs were laid, nor were any of the released mosquitos seen again.

It was observed in the laboratory that the "bite" of *Finlaya geniculata* is distinctly painful. The proboscis is large and the initial prick of the "bite" is sharp, but unlike the usual conditions when other mosquitos bite (a painless period following the initial prick when once the insect has got the proboscis well embedded in the tissues and has begun to feed), the initial prick from *Finlaya geniculata* is followed by a burning sensation, which continues and increases while the insect feeds; so much so that a good deal of will-power has to be exercised against the impulse to jerk the mosquito off. The subsequent effects of the "bite" are not, however, more serious than the usual effects of a mosquito bite.

Ochlerotatus caspius.

Normal conditions.—As larvae and pupae; found in numbers in a woodland pool near Ockham. As adults; not observed under natural conditions, but several bred out from larvae in the laboratory.

Conditions during drought.—As larvae and pupae; unobtainable; pool completely dried up since last May. As adults; unobtainable.

Ochlerotatus nemorosus.

Normal conditions.—As larvae and pupae; abundant in woodland pools and streams. As adults; very large numbers obtainable in the woods, where, particularly in the afternoons, they attack so persistently that there is no peace to be had.

Conditions during drought.—As larvae and pupae; unobtainable since the woodland pools dried up in May. As adults; unobtainable since about the middle of June, when it was found that even in the afternoons one might frequent the woods in peace, unmolested by a single mosquito—a state of affairs very different from what obtained during the whole of the summer months last year.

Ochlerotatus waterhousei.

Normal conditions.—As larvae and pupae; numerous in certain woodland pools. As adults; numerous in the woods where, associated with *Ochlerotatus nemorosus,* they persistently attack human beings, particularly in the afternoons.

Conditions during drought.—As larvae and pupae; unobtainable since end of May. As adults; unobtainable since May.

Theobaldia annulata.

Normal conditions.—As larvae and pupae; numerous in certain wayside ditches and in rain-water barrels. As adults; common in stables and outhouses, though never numerous.

Conditions during drought.—As larvae and pupae; unobtainable. As adults; a few still obtainable in pigsties in association with *Anopheles maculipennis.*

* * * * * * *

From the foregoing records it will be seen that drought tends to affect the mosquito population of an area adversely, decreasing the normal breeding-places, and in some instances, in the case of particular species, causing the normal breeding-places to disappear entirely. This is true for such species as *Anopheles plumbeus, Finlaya geniculata, Ochlerotatus caspius, Ochlerotatus nemorosus* and *Ochlerotatus waterhousei*. It will be interesting, therefore, to see whether these species will be

rare in this locality during future years. Predictions were made by several people at the beginning of the hot weather that there would probably be an enormous increase in the number of mosquitos all over the country, and that in consequence, with the large numbers of ex-soldiers in our midst who had suffered from malaria, we should probably see many new cases of indigenous malaria. The reverse has been true. I learn from the Ministry of Health that the number of cases of indigenous malaria contracted in England in 1920 was 36; whereas in 1921, up to the 29th August, only four cases had been recorded. Hot weather is obviously only one of the many factors in the malaria equation. Even in England, where it had been maintained that the historical epidemics of malaria have been occasioned by a hot summer following the return of malaria-infected troops from abroad, it will be clear that this combination is not all that is necessary to produce even a mild epidemic of indigenous malaria.

SOME COCCIDAE FROM EASTERN ASIA.

By G. F. FERRIS,

Stanford University, California.

Through the kindness of Professor E. O. Essig, of the University of California, I have been enabled to examine a collection of COCCIDAE from Formosa, made by M. Maki and S. Inamura, and also a small amount of material from Foochow, China, collected by Mr. C. R. Kellogg. It is upon this material that the present paper is for the most part based. In addition to this, I am taking advantage of the opportunity to rectify certain errors that have been made in the identification of a few species from Japan.

The material from Formosa is especially interesting, as nothing appears to have been published concerning the Coccid fauna of that island. The majority of the species here recorded are widely-distributed forms ; a few are known from Japan ; and several are species that have heretofore been recorded only from India, Ceylon and Java. While the number of species dealt with is not sufficiently large to permit of any generalisation, there is at least a suggestion that the Coccid fauna of Formosa is more closely related to that of southern Asia than to that of Japan.

The types of the new species here described are in the Stanford University Collection.

Icerya seychellarum (Westw.).

On *Morus alba* and *Citrus* sp., Taihoku, Formosa.

Icerya purchasi (Maskell).

On *Citrus* sp., Taihoku, Formosa.

Pseudococcus filamentosus (Ckll.).

On *Citrus* sp., Taihoku, Formosa.

Pseudococcus comstocki (Kuwana).

On *Citrus* sp., Taihoku, Formosa. Previously recorded from Japan and the United States.

Pseudococcus virgatus (Ckll.).

On *Baphinia* sp., Ako, Formosa.

Pseudococcus citri (Risso).

On *Morus alba*, Ako, Formosa.

Antonina bambusae (Maskell).

On *Bambusa stenostachya*, Taihoku, Formosa. This is the species that has ordinarily passed under the name of *Chaetococcus bambusae*. I am entirely in accord with Green in the opinion that *Chaetococcus* cannot be maintained as distinct from *Antonina*.

Antonina crawii (Ckll.).

1902. *Eriococcus graminis* (?) Maskell ; Kuwana, Proc. Calif. Acad. Sci. (3), 3 : 50.

On bamboo, Taihoku, Formosa. Kuwana (ref. cited) has recorded *Eriococcus graminis*, Maskell, from Japan. I have at hand the specimens upon which the record was based and they prove to be nothing more than immature stages of an *Antonina*, without much doubt *A. crawii*.

Cerococcus ficoides (Green).

On *Mallotus japonica*, Taihoku, Formosa. Previously known only from the original record, on tea from Bengal. The excellent description and figures given by Green render the identification practically certain.

Tachardia decorella (Maskell).

On *Ficus retusa* and undetermined host, Taihoku, Formosa.

Mallococcus sinensis (Maskell).

On undetermined host, Foochow, China. I have at hand part of the type material of this species and would redescribe it here (it is hardly or not at all recognisable from the original description) were it not that another author has a redescription now in press.

Ceroplastes rubens (Sign.).

On *Citrus*, Ako, Formosa.

Coccus bicruciatus (Green).

On *Murraya exotica*, Taihoku, Formosa. Previously recorded only from Ceylon.

Coccus elongatus (Sign.).

On *Acacia confusa*, *Codiaeum variegatum*, *Gossypium herbaceum*, *Hibiscus rosa-sinensis* and *Myrica rubra*, at Taihoku, and on *Morus alba* at Ako, Formosa.

Saissetia hemisphaerica (Targ.).

On *Gardenia florida*, Taihoku, Formosa.

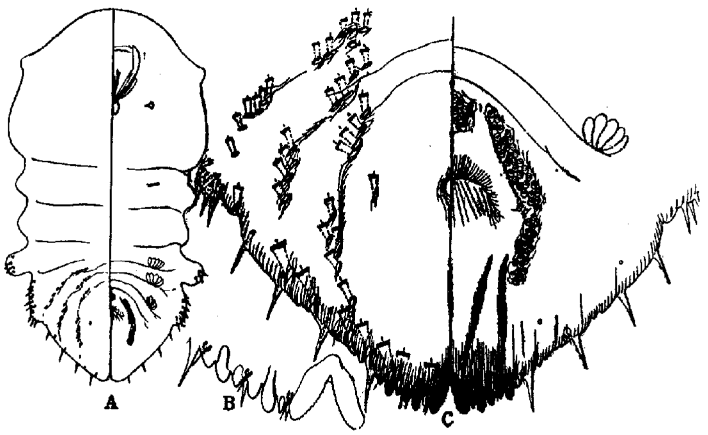


Fig. 1. *Aulacaspis cinnamomi* (Newstead): A, adult female; B, portion of pygidial margin; C, pygidium.

Aulacaspis cinnamomi (Newstead) (fig. 1).

On *Cinnamomum camphora*, Taihoku, Formosa. Previously recorded only from *Cinnamomum ceylanicum* in Java.

The specimens at hand differ somewhat from the figures given by Newstead, but these figures are not entirely clear, and in view of the close similarity in general appearance and in hosts I am inclined to assume that the figures are in error. I am presenting new figures. The species is certainly an *Aulacaspis*.

Aulacaspis rosae (Bouché).

On cultivated rose, Taihoku, Formosa.

Aulacaspis pentagona (Targ.).

On *Morus alba*, Taihoku, Formosa.

Fig. 2. *Aulacaspis tegalensis* (Zehntner): A, adult female; B, portion of pygidial margin; C, pygidium.

Aulacaspis tegalensis (Zehntner) (fig. 2).

On sugar-cane, Taihoku, Formosa. Previously recorded from Java and Mauritius. My determination is on the basis of specimens from Java.

I know of no figures of this species other than those given by Zehntner, which are in out-of-the-way publications and are in addition not especially satisfactory, and as the species is likely to be of some economic importance I am presenting new figures. I regard it as an *Aulacaspis* rather than a *Chionaspis*.

Phenacaspis eugeniae (Maskell).

On *Michelia fuscata*, Taihoku, Formosa.

The exact identity of Maskell's *Chionaspis eugeniae* appears to be in doubt, for there occurs in the Pacific region a series of forms which are very closely related. The Formosa specimens agree closely with examples from Hawaii which have been determined as *eugeniae*.

Chionaspis annandalei (Green).

On *Bambusa stenostachya*, Taihoku, Formosa. Previously known only from India.

Pinnaspis simplex, sp. n. (fig. 3).

From undetermined host, Foochow, China.

Scale of the female 1·5 mm. long, elongate, narrow, dark brown. Scale of the male not observed.

Female 0·9 mm. long, of the usual elongate form, the derm membranous throughout except for the pygidium. Margins of the abdominal segments projecting but little, without gland spines or at the most with a single gland spine on the last segment anterior to the pygidium, with numerous marginal ducts. Dorsum without ducts. Anterior spiracles with a small group of pores. Pygidium (fig. 3) acutely pointed, the median lobes alone developed, apparently fused, their outer edges crenulate. Extending into the pygidium from the median lobes is a slender, elongate median thickening. Beyond the median lobes there is first a small prominence followed by two setae, one of which has a conspicuously chitinised socket, a gland spine, two submarginal pores, a seta, a submarginal pore, two gland spines and a submarginal pore. Dorsum of the pygidium without pores except for the marginal series and a single pore representing the front row. Anal opening close to the anterior margin of the pygidium. Circumgenital pores in five groups.

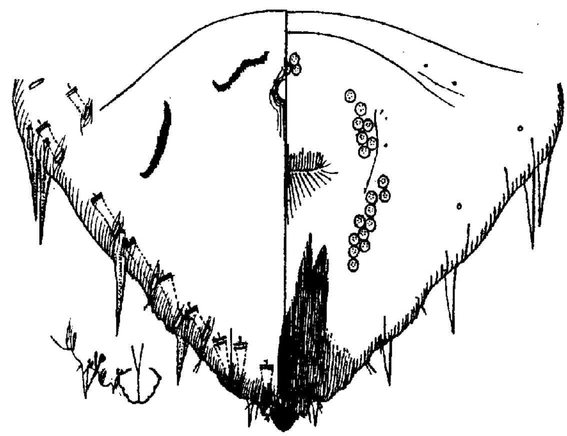


Fig. 3. *Pinnaspis simplex*, sp. n.: pygidium and portion of pygidial margin.

Notes.—Specimens of this species have been examined by Mr. E. E. Green, who agrees with me that it is undescribed. It is characterised by the single pair of lobes and is quite distinct from any other species known to me. I may note that I am considering the genera *Pinnaspis* and *Hemichionaspis* as synonymous.

Pinnaspis minor (Maskell).

On undetermined host, Taihoku, Formosa.

Parlatoria pergandei (Ckll.).

On palm (?), Foochow, China, and on *Thea sinensis* and undetermined host at Taihoku, Formosa.

Parlatoria zizyphi (Lucas).

On *Citrus* sp., Taihoku, Formosa.

Fiorinia japonica (Kuwana) (fig. 4, C).

1902. *Fiorinia fioriniae* var. *japonica,* Kuwana, Proc. Calif. Acad. Sci. (3), 3:79 (part).

From *Pinus thunbergii,* Taihoku, Formosa. Originally recorded from *Pinus* sp. and *Podocarpus chinensis* in Japan, the latter record in error.

In the original description of this species as a variety of *F. fioriniae* the type host was not designated. I find the material recorded by Kuwana to include two species and designate as a lectotype a specimen from *Pinus.* The specimens from *Podcarpus* I consider to belong to *F. juniperi,* Leonardi.

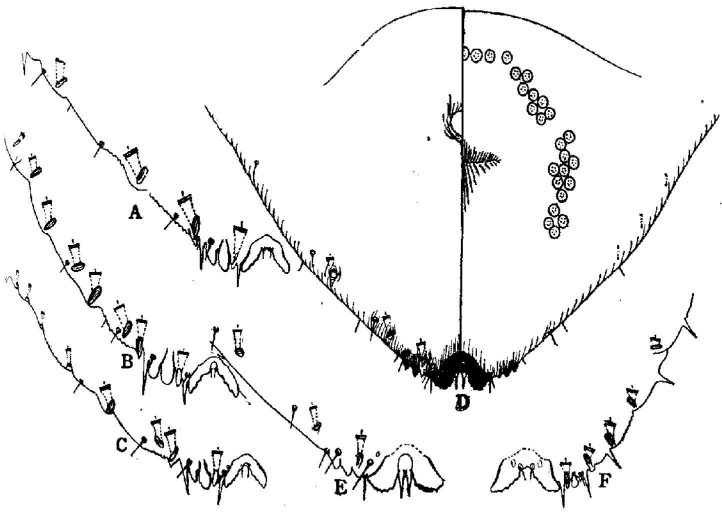


Fig. 4. Pygidial margins of : A, *Fiorinia fiorintae* (Targ.), from palm in the United States; B, *F. juniperi,* Leonardi, from *Podocarpus chinensis* in Japan; C, *F. japonica,* Kuwana, from *Pinus* in Japan; E, *F. chinensis,* sp. n.; F, *F. chinensis,* sp. n., second stage. D, pygidium of *F. chinensis,* sp. n.

Kuwana separated this form from *F. fioriniae* on the grounds of the larger number of circumgenital pores, but there appear to be more satisfactory characters in the number and arrangement of the marginal tubular ducts of the pygidium. In *F. fioriniae* (fig. 4, A) there are not more than four large ducts followed by as many small ducts. Otherwise the two species are very similar.

Fiorinia juniperi (Leonardi) (fig. 4, B).

1902. *Fiorinia fioriniae* var. *japonica,* Kuwana, Proc. Calif. Acad. Sci. (3), 3:79 (part).

Specimens from *Podocarpus chinensis* in Japan were included by Kuwana under *F. fioriniae* var. *japonica,* but I consider them to belong rather to *F. juniperi.* They agree very closely with specimens of *juniperi* (det. Green) from Ceylon. The species, like *japonica,* is very similar to *fioriniae,* but differs in having as many as eight large marginal ducts instead of four on the pygidium (fig. 4, B).

Fiorinia chinensis, sp. n. (fig. 4, D, E, F).

From undetermined host from China, taken in quarantine at San Francisco.

Scale not available for description.

Female 0·75 mm. long. Without a process between the bases of the antennae, with no pores about the spiracles and with at the most a very few small gland spines on the margins of the abdominal segments. Pygidium (fig. 4, D), with the median lobes quite large, rounded, minutely serrate, connected at the base and bounding a median notch in which are a pair of small gland spines. Second pair of lobes (fig. 4, E) represented merely by a pair of small tooth-like projections. Between the first and second lobes is the opening of a duct and beyond the second lobe are two more submarginal ducts, all quite small. Circumgenital pores present, forming an almost continuous arch.

Second stage without marginal projections on the abdomen, the pygidium (fig. 4, F) with a deep median notch, the median lobes narrower than in the adult, the second pair represented by a single undivided lobe. Lateral margins of the pygidium with several small gland spines and with five submarginal ducts.

Notes.—This species would appear to belong to Leonardi's genus *Trullifiorinia*, but I am not at present inclined to accept his groups. It somewhat resembles *F. rubrolineata*, Leon., but differs in the larger lobes and submarginal ducts.

Lepidosaphes beckii (Newman).

On *Murraya exotica*, Taihoku, Formosa.

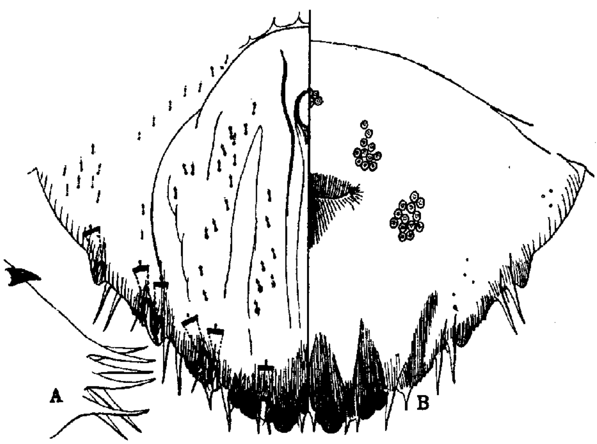


Fig. 5. *Lepidosaphes tubulorum*, sp. n.: A, lateral margin of abdominal segment; B, pygidium.

Lepidosaphes tubulorum, sp. n. (fig. 5).

1902. *Mytilaspis pomorum* (L.); Kuwana, Proc. Calif. Acad. Sci. (3), 3:80 (part).

Type from *Sapium sebiferum*, Taihoku, Formosa. Also from *Salix warburgi* at the same place, and from *Ilex crenata*, willow and currant in Japan.

Scales of male and female of the type common to the genus, dark brown, the former moderately broad, length 2·75–3 mm.

Female 1·1 mm. long, elongate, rather broad; the derm membranous except for the pygidium; the margins of the last three abdominal segments projecting and bearing numerous gland spines and likewise bearing a small spur-like, chitinised process (fig. 5, A). In some specimens this process may be developed on but part of the segments. Dorsum of the abdomen with large numbers of extremely small ducts.

Pygidium (fig. 5, B) with two pairs of lobes; the median pair widely separated, broad and with a deep subapical notch on each side, the second pair bilobed. Between the median lobes is a pair of small gland spines; between the median and second lobes a pore prominence with two small projections; beyond the second lobes a gland spine, a pore prominence with two large pores, two gland spines, two large marginal pores, two gland spines and two pores. Margins of the marginal pores heavily chitinised. Dorsal ducts extremely minute, arranged in three irregular areas somewhat variable in number. Circumgenital pores in five groups of 6–13 pores.

Notes.—The specimens recorded from Japan were included by Kuwana in *Lepidosaphes ulmi* (=*Mytilaspis pomorum*) along with specimens really referable to that species and others (from orchid) belonging to a species that I shall not here consider because of the scantiness of the material. While *L. tubulorum* is indeed quite similar to *L. ulmi*, it is readily separable by the small size and the arrangement of the dorsal ducts.

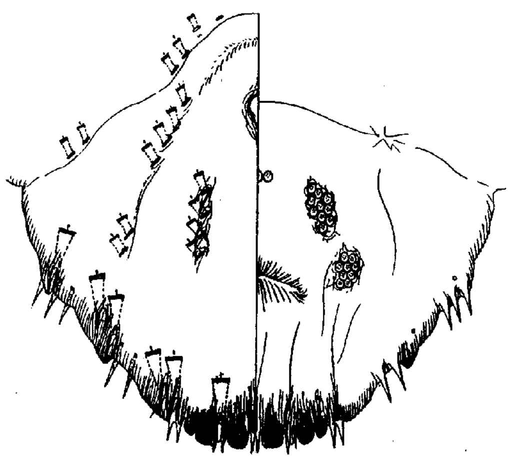


Fig. 6. *Lepidosaphes japonica*, Kuwana: pygidium.

Lepidosaphes japonica (Kuwana) (fig. 6).

1902. *Mytilaspis pomorum* var. *japonica*, Kuwana, Proc. Calif. Acad. Sci. (3), 3: 80.

From *Abies firma*, Japan.

I have at hand the types and type material of this species. It cannot be regarded as having any connection with *L. ulmi*, being in fact a very distinct species. I present the following notes.

Female with the derm unchitinised except for the pygidium. Margins of the abdominal segments projecting, the last three with three or more gland spines, the margins of both thorax and abdomen and the dorsum of the abdomen with numerous moderately large ducts. Pygidium (fig. 6) with two pairs of lobes, the median pair rounded, the second pair bilobed. Between the median lobes are two small gland spines; between the median and second lobes a pore prominence with two projecting points; beyond the second lobes two small gland spines, two large submarginal pores, two gland spines, two pores, three gland spines and a pore. Margins of the marginal pores heavily chitinised. Dorsal ducts only slightly smaller than the marginal ducts, arranged in three rows as indicated in the figure.

Genus **Pygalataspis**, nov.

Diaspidine COCCIDAE referable by the character of the ducts to the *Diaspis* series, that is with the ducts short, relatively broad and with a pair of transverse bars across the inner extremity. Ducts abundant on the pygidium, both dorsally and ventrally, not arranged in rows. Gland spines of the ordinary simple type lacking, being replaced by a series of short, broad, variously toothed plates along the margin of the pygidium, these plates apparently arising in part from the margins of the lobes. Two pairs of lobes or lobe-like processes present, the outer pair not bilobed. Circumgenital pores present in five groups. Scale of both sexes elongate, with the exuviae at one end, that of the female with the dorsal and ventral portions continuous, the ventral scale composed in part of the ventral portion of the second exuviae.

Type of the genus, *Pygalataspis miscanthi*, sp. n.

Notes.—In the abundance and distribution of the ducts and the correlated characters of the scale this genus most closely resembles *Odonaspis*, but the peculiarly shaped plates and the extraordinarily large lobes are quite unlike anything else with which I am familiar. The genus *Odonaspis* is usually attached to the *Aspidiotus* series of the DIASPIDINAE, but I am inclined to doubt the correctness of this placing, regarding it rather as belonging to the *Diaspis* series.

Pygalataspis miscanthi, sp. n. (fig. 7).

From *Miscanthus sinensis* (a grass), Taihoku, Formosa.

Scale of the female about 2·5 mm. long, elongate, white or brownish; scale of the male similar in form and colour to that of the female, about 1 mm. long.

Female (fig. 7, B) elongate, with nearly parallel sides, the margins of the abdominal segments projecting but little or not at all, the derm membranous except for the pygidium and the lateral margins of the last two or three abdominal segments which are heavily chitinised. Lateral margins of the metathorax, and of all the abdominal segments and the dorsum of the last two segments with numerous ducts of the type shown in fig. 7, D.

Pygidium (fig. 7, A) with the marginal area heavily chitinised and more or less folded. Two pairs of large, rounded lobes or lobe-like processes present, each with a broad, flattened, irregularly toothed plate arising from the outer margin, the plates of the second pair larger than those of the median pair. Beyond the second is a cluster of two or three smaller plates. Setae at the bases of the lobes, both dorsally and ventrally, long and slender. Tubular ducts very abundant, all small, those of the venter confined to a broad marginal zone. Circumgenital pores in five groups of 15 or more pores.

Second stage with the pygidium (fig. 7, C) terminating in a pair of prominent, pointed processes, which bear small plates as in the adult, and with a few small plates

along the lateral margin beyond the lobes. Ducts few, relatively large, confined to a submarginal series. Second exuviation occurring by the splitting of the derm about the posterior lateral margin, the ventral portion becoming incorporated in the ventral scale.

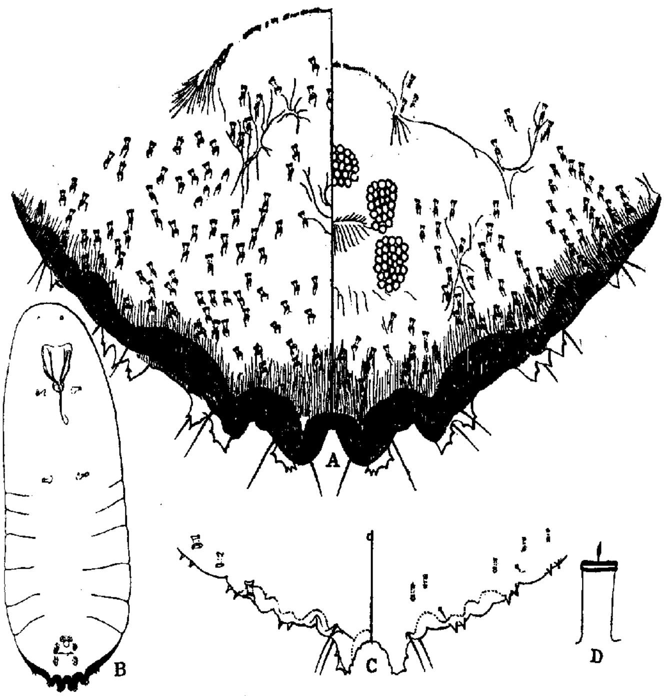


Fig. 7. *Pygalataspis miscanthi*, sp. n.: A, pygidium; B, adult female; C, pygidial margin of second stage; D, type of duct.

Odonaspis penicillata (Green).

1902. *Aspidiotus inusitatus*, Green; Kuwana, Proc. Calif. Acad. Sci. (3), 3 : 65 (misidentification).

On *Bambusa stenostachya*, Taihoku, Formosa. Specimens recorded from Japan as *O. inusitata* by Kuwana (ref. cited) are this species instead.

Aspidiotus lataniae (Sign.).

On *Morus alba*, Ako, Formosa, and undetermined host from Formosa in quarantine at San Francisco.

Chrysomphalus aurantii (Maskell).

On *Citrus* sp., Taihoku, Formosa.

Chrysomphalus aonidum (L.).
On *Cycas revoluta*, Ako, Formosa.

Pseudaonidia duplex (Ckll.).
On *Michelia fuscata*, Taihoku, Formosa.

Pseudaonidia trilobitiformis (Green).
On *Citrus* sp., Taihoku, Formosa.

THE LARVAL AND PUPAL STAGES OF THE BIBIONIDAE.

By HUBERT M. MORRIS, M.Sc., F.E.S.

Entomological Department, Institute of Plant Pathology, Rothamsted Experimental Station, Harpenden.

Several species of BIBIONIDAE are very common in the adult state during the spring and early summer in Britain, but their larvae seem to have been very little studied. The latter frequently occur in large numbers together, and are from time to time reported to have caused damage to various crops.

Probably the commonest species of *Bibio* are *B. marci* and *B. johannis,* but several others are also very frequently met with. The life-history of *Bibio johannis,* L., has been fully dealt with previously (6), and in the present paper it is proposed to give some account of the life-histories of *Bibio marci,* L., *B. lacteipennis,* Ztt., and *B. venosus,* Mg.

I am greatly indebted to Dr. A. D. Imms for suggestions and advice during the course of this work, and for the material of *Bibio venosus,* and to Mr. F. W. Edwards for identifying the adults which have been reared.

Bibio marci, L.

Oviposition.

In the early part of May 1920, a number of adults of *Bibio marci,* of both sexes, were captured and placed in a glass jar, the top of which was covered with gauze.

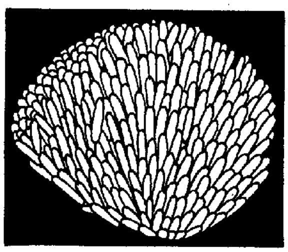


Fig. 1. Eggs of *Bibio marci,* × 6.

At the bottom of the jar a layer about 3 cm. in depth of fine damp soil was placed The flies were fed on sweetened water, and by this means it was found possible to induce the females to oviposit. After a day or two, the time probably varying with their age when captured, females were seen making their way into the soil. This is accomplished almost entirely by means of the fore legs, which are moved up and down in front of the head, with their tarsi bent back, the actual pressing back of the soil being done by the distal ends of the tibiae. In this manner a burrow just large enough to contain the fly is made, the insect turning over from time to time so that the soil is pressed aside in all directions. The burrows have a very irregular course, but the flies gradually make their way downwards into the soil.

At a little distance below the surface, the depth varying in different cases, a small cell is constructed which is of greater diameter than the burrow, and in this cell a mass of eggs is deposited, the eggs being arranged in an orderly manner (fig. 1).

antennae are exceedingly small and inconspicuous, being situated just above the bases of the mandibles. The structures which were previously considered to be the antennae (6) are lateral protuberances of the labrum.

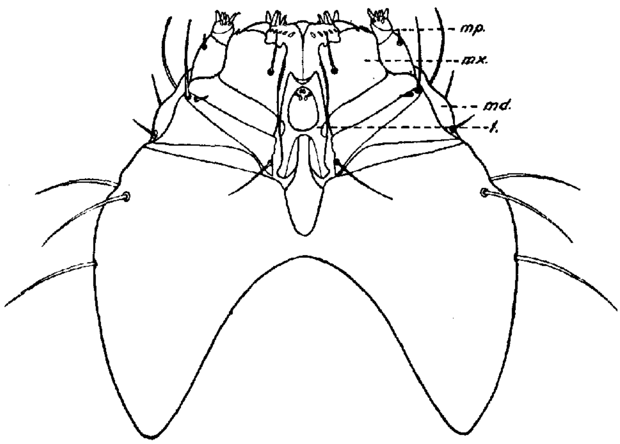


Fig. 5. Head of fully grown larva of *Bibio marci*, ventral view, × 53 ; *l*, labium ; *md*, mandible ; *mp*, maxillary palp ; *mx*, maxilla.

The body is nearly cylindrical, but somewhat flattened dorso-ventrally, and normally is slightly curved, the ventral surface being concave. The body is divided into twelve segments, of which the first is the longest. It bears ten pairs of spiracles, which are situated a pair on each segment except the second and eleventh, and project slightly from the body. The spiracles on the first segment are about twice the size of those on segments 3 to 10, and those on segment 12 are about four times the size of those on segments 3 to 10, and each one has two openings.

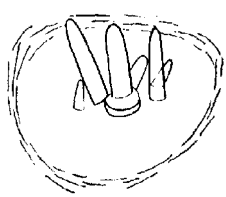


Fig. 6. Antenna of larva of *Bibio marci*, × 580.

Each segment bears a number of stout conical processes, which are arranged more or less in rows, on both the dorsal and ventral surfaces, the more lateral processes in the rows being usually at least twice as long as the median ones. The arrangement of these processes does not appear to vary in the different species of *Bibio* which have so far been examined.

The spiracles of the first segment are situated laterally near the posterior boundary of the segment. Dorsally the segment bears two rows of processes, each row containing eight processes, the lateral processes of the second row being slightly

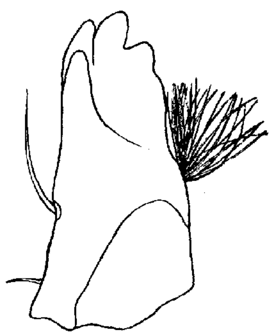


Fig. 7. Right mandible of larva of *Bibio marci*, ventral view, × 100.

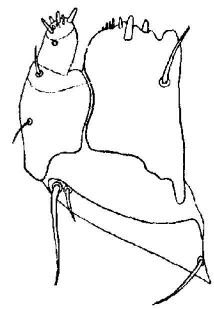


Fig. 8. Right maxilla of larva of *Bibio marci*, ventral view, × 100.

displaced forwards by the spiracle. Ventrally the segment bears three incomplete rows. The first row consists of two processes; the second of four, one pair near the median line and the other pair lateral; in the third row there are four processes.

The second segment, which has no spiracles, bears a row of eight processes dorsally and another row of eight processes ventrally; the median pair in the latter row is situated nearer to the anterior margin of the segment than the remainder.

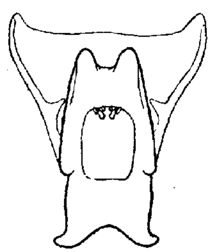


Fig. 9. Labium of larva of *Bibio marci*, ventral view, × 100.

The third segment bears a pair of spiracles laterally towards its anterior margin; dorsally it bears a row of eight processes, and ventrally a similar number, of which the middle pair is placed forwards as on the second segment.

The fourth segment bears a pair of spiracles in a similar position to those on the third segment. Dorsally this segment bears a row of eight processes, the lateral

pair being slightly nearer the anterior end than the remainder. On its ventral surface this segment bears two rows of processes, the first row containing six and the second four. The segments five to ten are similar to the fourth segment.

On the dorsal surface of the eleventh segment there is a row of six large processes near its posterior margin, of which the median pair is the largest. There is a single lateral process on each side near the anterior border of the segment and on the ventral side there are six processes.

The twelfth segment bears a pair of large spiracles anteriorly, which are placed in a more dorsal position than those on the other segments. Posteriorly it bears a row of four large dorsal processes, the median pair being the largest on the body. On the ventral surface of this segment there is a single pair of processes.

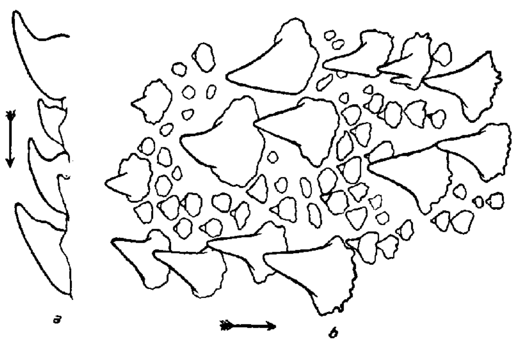


Fig. 10. Portion of cuticle of *Bibio marci* larva from dorsal surface of fourth segment; *a*, lateral view; *b*. surface view; the arrows directed anteriorly ; × 330.

The cuticle with which the body is covered bears many small scale-like structures, which are packed especially closely together on the processes. The largest of these scales bear stout backwardly-directed spines of a darker colour than the remainder of the cuticle (fig. 10). The scales on the first, second and third segments, and some on the ventral surface of the twelfth segment, bear from one to four spines, and those on the remaining segments usually carry a single stout spine, but a second more slender spine is present on certain of the scales. The scales on the base of the processes all carry several spines, but those on the upper part have only a single spine.

The alimentary canal (fig. 11) takes an almost straight course through the body, but has a loop near the posterior end, in the hind gut. The largest part of the alimentary canal is the mesenteron, which bears three large caeca at its anterior end, one lying on each side and the third, which is the largest, placed ventrally.

The four Malpighian tubes join the alimentary canal at the junction of the mesenteron and hind gut, entering the canal by a short common duct on the dorsal side. There is no posterior caecum such as is found in connection with the alimentary canal of *Bibio johannis*.

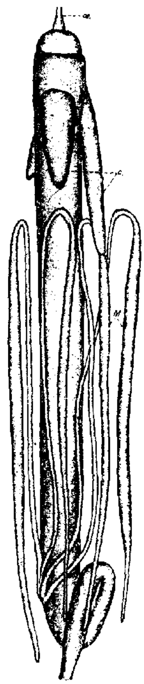


Fig. 11. Alimentary canal of larva of *Bibio marci*, lateral view, × 5; *c*, caeca; M, Malpighian tubes; *oe*, oesophagus.

Pupa.

Elongate, cylindrical, tapering gently to posterior end, abruptly at anterior end. Completely free from larval skin. Colour at first white, head and thorax of imago showing dark through cuticle later. Length from head to tip of abdomen, ♂, 12·5 mm.; ♀, 15 mm. (fig. 12). Head with very slight, blunt, anterior, median process; a slight median dorsal ridge extending from the anterior median process to posterior margin of thorax, dehiscence for emergence of imago occurring along this ridge. Antennae extremely short, arising between bases of eyes, extending laterally over eyes. In the males, eyes large and protruding; in female, smaller and less conspicuous. Labium elongate, semicircular; labial palpi elongate, conical, extending laterally. Dorsally, most of head covered by prothorax, only eyes of male visible.

Thorax strongly arched dorsally. Pair of thoracic spiracles slightly projecting laterally. Tibiae and tarsi of fore legs extending from side of eyes level with antennae to anterior margin of second abdominal segment, with tarsi in apposition along median line. Second and third pairs of legs parallel to first, all except tibiae and first and last tarsal segments of second and last tarsal segment of third, covered by wings ; last tarsal segments appearing posterior to those of first leg, and those of each pair in contact along median line.

Fig. 12. Pupa of *Bibio marci*, ♂, ×5.

Abdomen nine-segmented ; length of segments in proportion 7, 10, 11, 12, 12, 11, 10, 9, 9 ; width of segments decreasing gradually towards posterior end. Cuticle with many fine wrinkles, mainly transverse ; on abdominal segments, dorsally and ventrally, bearing numerous spines similar to, but less stout than, those of larva, occurring singly or in groups of two to four, on slight swellings of cuticle. Terminal segment (fig. 13) bluntly conical, bearing a pair of stout, dark brown, sharply pointed processes at the posterior end, directed posteriorly and outwardly, and a pair of rounded papillae. All segments except eighth bearing a pair of slightly projecting spiracles laterally, towards the anterior margin of the segment.

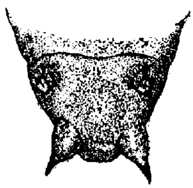


Fig. 13. Posterior extremity of pupa of *Bibio marci*, ♂ dorsal view, × 18.

Bibio lacteipennis, Ztt.

A number of larvae which proved to be those of *Bibio lacteipennis*, Ztt., were found in a plant pot at Withington, Manchester, during February 1918. The larvae were kept in some of the same soil, which was a rich leaf-mould in which bulbs had been grown, in the laboratory, and the first pupa was seen on 23rd March, and the first adult appeared on 13th April.

Larva.

It is proposed to point out the differences between the larva of this species and that of *Bibio marci*, L., which has been described above.

The most obvious differences between these two species are the smaller size of the larva of *B. lacteipennis* and the fact that the processes on its body are relatively more slender. The number and arrangement of the processes on all the segments is the same in both species.

The most striking difference is exhibited in the cuticle. In both species the cuticle of the full-grown larva bears a great number of small, irregularly-shaped, scale-like structures. In *B. marci* the largest of these scales bear one stout spine, while in *B. lacteipennis* (fig. 14) the scales are much less well developed, and only those on the processes, and on the anterior part of the ventral side of the first segment of the body, bear these spines. The latter are, moreover, less stout than those of *B. marci*, and there do not seem to be more than two on any scale. On the ventral surface of the twelfth segment a few of the scales bear single, long, stout spines.

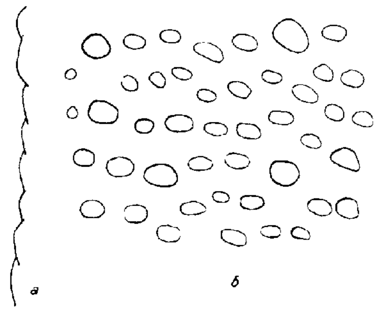


Fig. 14. Portion of cuticle of larva of *Bibio lacteipennis* from dorsal surface of fourth segment: *a*, lateral view; *b*, vertical view; × 330.

The only apparent difference in the mouth-parts is the presence of a slight median projection between the two processes at the anterior end of the submentum.

The larva bears a pair of protrusible pseudopod-like structures at the end of the twelfth segment, which are relatively larger and better developed than is the case in *B. marci*.

The alimentary canal, Malpighian tubes and caeca appear to be similar to those of *B. marci*, and there is no posterior caecum.

The length of the full-grown larva is about 15 mm.

Pupa.

The pupa of *Bibio lacteipennis* bears a considerable resemblance to that of *B. marci*. It is distinguished from the latter by its smaller size and the somewhat greater development of the median process at the anterior end. The male pupa bears a pair of small, blunt processes, slightly ventral to the median process and situated on the anterior portion of the eyes. Length of pupa 7 to 7·5 mm.

Bibio venosus, Mg.

Larva.

A few larvae of this species were found in leaf-mould at Brockenhurst on 22nd March 1920, but unfortunately before they could be thoroughly examined they had all pupated.

The mouth-parts do not show any noticeable difference from those of *Bibio marci*, and the number and arrangement of the spiracles and processes is similar. With this larva again, as in the case of *B. lacteipennis*, the chief difference from *B. marci* is in the scales on the cuticle. As in *B. lacteipennis*, these scales are very slightly developed and do not bear spines, except those on the twelfth segment

and occasional ones on other segments, which bear a single, short, blunt spine. The scales in this larva are much more regular and are placed more closely together than in any other species so far examined (fig. 15).

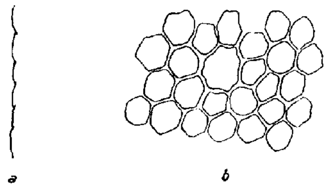


Fig. 15. Portion of cuticle of larva of *Bibio venosus* from dorsal surface of fourth segment: *a*, lateral view; *b*, vertical view; × 330.

Pupa.

This pupa again bears a considerable resemblance to that of *B. marci*, from which it also differs in its smaller size; in the greater development of the process at the anterior end, which is slightly larger than that of *B. lacteipennis*; and in the presence in the male of a pair of similar blunt processes on the anterior portion of the eyes. The eyes in the male of this species are rather smaller than in the two species previously described. Length of pupa 10 to 11·5 mm. In the laboratory the pupal state lasted 19 days.

Differences between Larvae of various Species.

In the foregoing descriptions of *Bibio* larvae it will be noticed that attention is drawn to the differences in the cuticular structures in the different species dealt with. These differences seem so far to be sufficiently distinct and regular to give

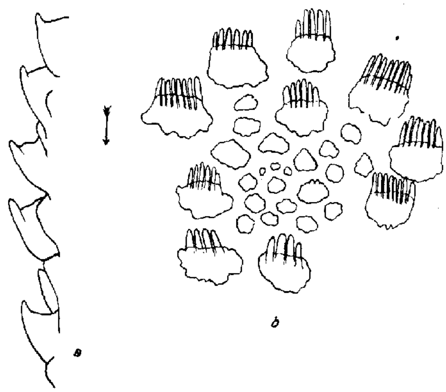


Fig. 16. Portion of cuticle of larva of *Bibio johannis* from dorsal surface of fourth segment: *a*, lateral view; *b*, vertical view; × 330.

a ready means of distinguishing between the species in the larval state. There are many other species of *Bibio*, the larvae of which have not yet been examined, but it is possible that some such distinction may hold good throughout.

In addition to the three species described above, larvae of *Bibio johannis*, L. (fig. 16), have been examined, and also larvae believed to be those of *B. pomonae*, F. (fig. 17), but the latter were not definitely identified in the adult state. As will be seen from the illustrations, these two species are quite distinct from the other species figured.

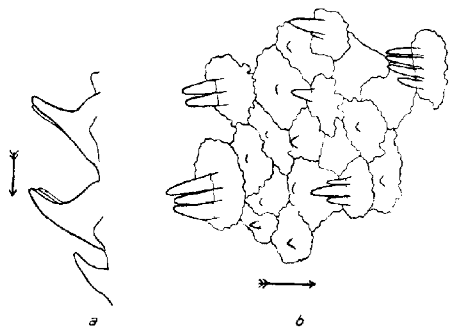


Fig. 17. Portion of cuticle of larva of *Bibio pomonae* from dorsal surface of fourth segment : *a*, lateral view; *b*, vertical view; the arrows directed anteriorly; × 330.

The alimentary canal also varies in some of the species examined, that of *B. marci* and *B. lacteipennis* being without the posterior caecum which is present in the canal of *B. johannis*. This posterior caecum is also absent, according to Keilin (4), from the alimentary canal of *B. hortulanus*, L. The labium also shows slight variations in different species.

Parasites of Bibionid Larvae.

Very few parasites of the BIBIONIDAE are known. In addition to the mite and nematode recorded by Lyonet, Keilin (4) mentions the Gregarine *Schneideria mucronata*, Leger, occurring in the mid-gut and anterior caeca of Bibionid larvae, and also a bacterial disease. He further mentions a Microsporidian, probably a *Glugea*, which invades the epithelial cells of the mid-gut and caeca of Scatopsid larvae.

Sorauer (7) gives *Agyrtes bicolor* as a parasite of the larvae of *Scatopse*.

A Gregarine, probably the *Schneideria* mentioned by Keilin, was found in the posterior caecum of a *Dilophus febrilis* larva, and in the same larva two cysts full of spores were found free in the body. Another parasite, probably the *Glugea* mentioned above, was found infesting the epithelium of the alimentary canal in a *Bibio johannis* larva.

In addition to these a Dipterous parasite was met with in connection with *Bibio marci* larvae. This was the Phorid *Hypocera incrassata*, Mg. The fully grown larvae emerged from the *B. marci* larvae when the latter were about to pupate, and almost immediately entered the pupal state. Only a single parasite was observed in each larva attacked.

Additions to Literature since 1917.

In 1917 an account of the larva and pupa of *Bibio johannis* was published, in which the literature up to that date was referred to. The following publications have appeared since that date.

A brief account, with figures of the larva, pupa and adult, of *Plecia fulvicollis*, F., an Indian Bibionid, has been published (3). Keilin (4) has given a short account of the alimentary canal in *Scatopse notata*, *Bibio hortulanus* and *Dilophus febrilis*. That of *B. hortulanus* resembles the alimentary canal of *B. marci* in the absence of the posterior caecum, which however is present in a well developed state in *Dilophus febrilis*.

A few additional records of damage to crops by Bibionid larvae have been published also. Carpenter (1) records *Bibio* larvae as having caused much damage in wheat fields in Co. Cavan, Ireland, in March 1918, by eating the roots of the plants; and *Bibio marci* larvae are reported to have damaged potatoes in a " pit " in Co. Louth, in October 1916.

Molz (5) records *Bibio hortulanus* larvae as damaging potatoes near Halle in September 1918 by eating beneath the skin. It was noticed that only parts of the field which had been treated with stable manure were infested. Afterwards winter wheat was sown and larvae were found to be feeding on the seed. In experiments it was found that the larvae attacked the seed at the point of germination, and also that only potatoes which had previously been injured were attacked. Potato skins steeped in a 1 per cent. solution of arsenious acid were found to form an attractive and effective poison bait.

1. CARPENTER, G. H. (1920). " Injurious Insects, etc., in Ireland during 1916, 1917 and 1918." Econ. Proc. Roy. Dub. Soc., ii, No. 15, Nov. 1920.

2. CURTIS, J. (1844). " *Bibio marci*." Gardeners' Chronicle, 16th Nov. 1844, p. 764.

3. FLETCHER, T. B. (1919). " Second Hundred Notes on Indian Insects." Agric. Research Inst., Pusa, Bull. 89, p. 58.

4. KEILIN, D. (1919). " On the Alimentary Canal and its Appendages in the Larvae of Scatopsidae and Bibionidae (Diptera Nematocera), with some Remarks on the Parasites of these Larvae." Ent. Monthly Mag. (3) v, pp. 92–96.

5. MOLZ, E. (1920). " Weitere Beiträge zur Kenntnis der Gartenhaarmücke (*Bibio hortulanus*, L.)." Zeitschr. angew Entom. Berlin, vii, No. 1, Sept. 1920. pp. 92–96, 3 figs. (Abstract in *Rev. App. Ent.*, 1921, p. 1).

6. MORRIS, H. M. (1917). " The larval and pupal stages of *Bibio johannis*, L." Ann. App. Biol. iv, 3, pp. 91–114.

7. SORAUER, P. (1913). Handbuch der Pflanzenkrankheiten, iii, p. 458.

Fig. 1. A typical case of " Simulium disease."

Fig. 2. Chemosit River flowing through forest heavily infested with *Simulium*.

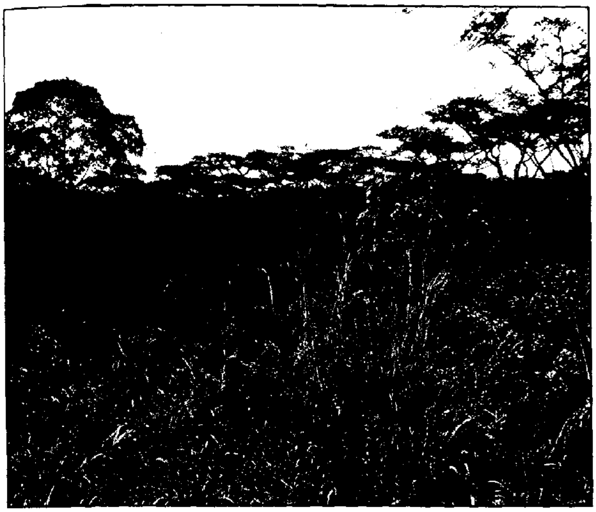


Fig. 1. Dense thorn forest heavily infested with *Simulium*, Lumbwa Reserve, Kenya Colony.

Fig. 2. Thin thorn forest, adjoining that in Fig. 1, lightly infested with *Simulium*.

TRYPANOSOMIASIS IN THE ABSENCE OF TSETSES, AND A HUMAN DISEASE POSSIBLY CARRIED BY SIMULIUM IN KENYA COLONY.

By F. W. Dry, M.Sc.,

Recently Assistant Government Entomologist, Kenya Colony.

(Plates VII & VIII).

This is an account of two different inquiries carried out on the same safari in the Lumbwa country of Kenya Colony early in 1920. The problems are of the same type, the suspected transmission of disease by blood-sucking flies, and the second investigation arose out of the first. It therefore seems best to deal with them both in a single paper.

In March 1920, in the absence of my Chief, Mr. T. J. Anderson, I was asked to make a fly survey in the neighbourhood of a farm in the Kericho district where cases of trypanosomiasis had been demonstrated. I arrived at this farm on 25th March. The blood-sucking flies collected are listed below. As was anticipated, the altitude being about 6,300 ft., and there being no records of tsetse-fly anywhere near, none was found. I was then fortunate in receiving information from Mr. Ian Q. Orchardson, the pioneer settler of the Kericho district, about a small blood-sucking fly to be found in the forest in part of the Lumbwa Reserve. The bites of this fly, he told me, are believed by the Lumbwa to be the cause of a disease from which some of the inhabitants of that region suffer. He further suspected that this fly might transmit a disease of cattle. Accordingly, on 7th April, I proceeded into the area about which he had told me in the Lumbwa Reserve, also crossing the Kipsoni into adjacent country of the Kisii Reserve. The fly proved to be a *Simulium*. I satisfied myself that it could not be regarded as the transmitting agent of any cattle disease, but did obtain evidence which shows that the belief of the Lumbwa calls for further investigation. On 29th April, I returned to the farm near Kericho, to search for *Simulium* there, but failed to find it, staying there until 3rd May.

I. Possible Transmission of Trypanosomiasis in the Absence of Tsetses.

The presence of trypanosomiasis on the farm near Kericho was demonstrated from blood-slides taken by the late Captain J. Cameron, Veterinary Officer, and examined by Mr. W. Kearney, Assistant Veterinary Pathologist. His diagnosis of the type of trypanosome was confirmed by Mr. R. E. Montgomery, now Veterinary Advisor in Uganda, who wrote to Mr. Kearney in January 1920:—" On purely morphological features, the trypanosomes . . . . . are recognisable as *Tr. uniforme*. The bold body, slightly developed, undulating membrane, short, free flagellum, distinct blepharoplast and clear cytoplasm all point to this species, or a near relative of the *vivax* group."

The farm where the outbreak occurred was a new one, and all the cattle on the farm, other than those of native squatters, were working oxen which had been bought and brought on to the farm towards the end of 1919 or early in 1920.

In 1919 there had been no deaths of oxen, apart from one animal which died after an accident, but from early January up to my arrival there had been a high mortality, and trypanosomiasis had been demonstrated from blood slides in some cases. Particulars about the losses up to the time of my visit are as follows:—

Total number of European owned oxen	63
Deaths:—	
Trypanosomiasis proved by blood-slides	2
Not due to any disease	2
Cause not proved	14

Ten cases of trypanosomiasis were proved from blood-slides, all taken previous to the 6th April, and eight of the oxen were still alive at the time of my visit.

After my visit the mortality ceased. No more cases of the disease were detected, and all animals proved to be infected were slaughtered in order to bring the outbreak to a close.

It should here be mentioned that two farmers resident for some years in the district told me that when cattle are brought from other parts of the country to poor grazing of the sort on this farm and worked hard, as the oxen had been, there is great risk of loss. This, it seemed, might be the explanation of some of the deaths. With the fact, however, that, in all, ten cases of trypanosomiasis were proved, and that no other disease had been demonstrated on the farm, the presumption certainly is that some of the fourteen deaths of which the cause was not known were due to trypanosomiasis.

There were no signs of the disease amongst the small number of cattle owned by Lumbwa on the farm. The European and native owned animals were kept away from each other.

The European owned oxen had all been bought from dealers, two European and two Indian. Those obtained from the European dealers had been through the Kibigori Quarantine Station, to which animals were taken from widely separated sources; those from Indians had probably come out of the Lumbwa Reserve.

Of the ten animals proved to have trypanosomiasis two had been purchased from one European dealer, two from the other, and the remainder from one or other of the two Indian dealers. A sufficiently accurate record had not been kept to make it certain whether animals which had the disease had come from one Indian dealer or from both, but the partner on the farm in charge of the cattle felt almost certain that it was from both. At any rate, animals from three out of the four sources had trypanosomiasis, and though there is just a chance that both the European dealers had bought cattle from the same mob from Kibigori, the number of distinct sources from which animals proved to have trypanosomiasis had come is at least two, though it may be four.

Another point to be noted is that the second animal which was proved to have the disease came on to the farm early in February, having been purchased from one European dealer, after the death, on 1st February, of the first animal proved to have the disease, which had been bought from the other European dealer.

One piece of information given to me must now just be mentioned about the possible presence of trypanosomiasis cases other than oxen on the farm. A Dutch manager who had left the farm had had two donkeys. One donkey is believed to have died or been killed on the farm in November or December of 1919. The other had been given to a Kericho resident and had subsequently died. This manager was stated to have thought that the donkeys had trypanosomiasis. This evidence is not of a definite description, but is recorded because Captain Cameron inclined to the view that it might have been in these donkeys that the disease was brought on to the farm.

I collected blood-sucking flies on this farm and on neighbouring land, near to the river known at different parts of its course on the farm boundary as the Saosa, the Dimbilitch, and the Kitho, near to small tributary streams, and on the grazing grounds of the cattle, which were then being kept away from the river. The blood-sucking fly fauna could not be considered a striking one. All such flies captured belonged to the genera *Haematopota* and *Stomoxys*. *Stomoxys* were chiefly captured on grazing oxen, often being present in large numbers, while almost all the *Haematopota* were taken near to the river.

While in the Lumbwa and Kisii Reserves I was collecting blood-sucking flies at various lower points on the same river system, as far as a point on the Sondo River about fifteen miles in a direct line from the farm, and with the exception of a *Simulium*, to be referred to shortly, the only specimen taken of a fly of any additional genus was a single individual of *Tabanus taeniola*, P. de B., var. *variatus*, Walk., captured in the Lumbwa Reserve about ten miles due west of the farm. While it is not impossible that that fly might be taken on the farm, it can hardly be common there. The Lumbwa herd-boys on the farm told me that my captures included specimens of all the blood-sucking flies which they knew to be there.

The cattle on the farm were not dipped and some ticks were collected from them.

The species of blood-sucking flies and ticks taken were the following :—

Haematopota similis, Ric.—10 ♀♀.
,, *hirta*, Ric.—2 ♀♀.
,, *brunnescens*, Ric.—11 ♀♀.
,, *alluaudi*, Surc.—5 ♀♀.
,, *ugandae*, Ric.—28 ♀♀.
Stomoxys calcitrans, L.—15 ♂♂, 22 ♀♀.
,, *varipes*, Bezzi—3 ♀♀.
,, *nigra*, Macq.—1 ♀.
Amblyomma variegatum, F.
Boophilus sp.

Mr. Orchardson told me of an extensive area of thick thorn forest in the Chemosit River district of the Lumbwa Reserve which the Lumbwa leave almost uninhabited owing to its being infested with a fly which proved to be a *Simulium*. The belief of the Lumbwa, about which he told me, that the bites of this fly cause a disease of human beings will be discussed directly. He further suspected that this fly might be the carrier of some disease of cattle. In 1917 he and a neighbour carted maize to their farms near Kericho from Litun, and outspanned their oxen just off the Sotik Road near to the Chemosit and Jamji Rivers. Afterwards some of the oxen used in this work died, each planter losing about half a dozen animals. "These," he said, "gradually faded away and died." Some were ill for weeks, some for months. They were not seen by any veterinary officer. Now there is a considerable area of thorn forest on and near the farm where the outbreak of trypanosomiasis had occurred, so this was a suggestion to be followed up.

My inquiry, however, yielded negative results, for :—

(*a*) Those Lumbwa who live in the infested area keep cattle. One young man had come two years ago from a district clear of *Simulium* in order to graze his father's cattle in the infested country, for much of the grazing is good.

(*b*) The people told me that *Simulium* bites cattle, sheep and goats, but they said that it does not give the animals any disease.

(*c*) It was pointed out to me by Mr. C. M. Dobbs, the District Commissioner at Kericho, that cattle are frequently outspanned just off the Sotik Road in the same place as those of Mr. Orchardson and his neighbour, but he had not heard of any other cases of disease supposed to have been contracted there like that of which Mr. Orchardson had spoken.

(*d*) I failed to find *Simulium* so far east as the Sotik Road, the nearest point where a specimen was captured, and that at a place where *Simulium* was not numerous, being a mile and a half to the west, though it is not impossible that the fly may occur on the road in small numbers.

After this visit to the Reserves I returned to the farm of the outbreak and again collected blood-sucking flies there and in the thick thorn forest on adjacent land,

searching especially for *Simulium* but finding none. Inquiries were made from a large number of natives, who replied, either that they knew nothing at all about the fly, or that they knew of it near the Chemosit River.

Simulium was therefore not a factor in the presence or transmission of trypanosomiasis on the farm where this outbreak had occurred.

The evidence recorded above, combined with the fact that no other outbreak of trypanosomiasis was recorded in the district, points to the probability that the disease was transmitted on the farm to healthy animals from one or more animals which were infected when they came on to the farm. If that be so, suspicion would fall first on *Stomoxys*.

II. Possible Connection of *Simulium* with a Disease of Human Beings.

The Lumbwa name for this *Simulium* is "kekonjek." A place infested with *Simulium* is spoken of as "kapkekonjek." The insect has been identified by Mr. F. W. Edwards, of the British Museum, as *Simulium neavei*, Roubaud.

The badly infested country, so far as I was able to ascertain from my own observations and from inquiries from the Lumbwa, is covered with dense forest, mostly of thorn trees, white and red, with occasional open spaces (see Plates vii and viii). It is well watered, and it is unlikely that there is any point within that area much more than two miles from some stream, large or small. About three miles below the junction of the Chemosit and Kipsoni Rivers one fly was captured, this being the lowest point reached on that river on the trip ; *Simulium* was present there in only small numbers and it was evident that, lower down, neither the Lumbwa on the right bank of the river, nor the Kisii on the left, paid any attention to the fly. It was also taken in small numbers in a tributary valley of the Sondo River on the left bank a mile from the Sondo ; in this valley there were scattered clumps of trees but not continuous forest.

The flies are appreciably less numerous in thin than in thick forest (see Plate viii), and while present in the middle of open spaces—say a quarter of a mile in diameter—are there distinctly less numerous than in the forest. This falling off in numbers as one gets away from dense forest is quite a sudden one.

The flies are active, the Lumbwa told me, and my own observations are consistent with what they said, from about seven o'clock in the morning until five in the afternoon, and especially so in the afternoon. Very little is seen of them when rain is falling, and I was told, and from my own collecting believe it to be so, that the flies are not so active in intense sunshine as when the sun is less bright. They pay little attention to people on the march, but if one remains still in infested country they appear immediately. They bite very readily and often raise half-inch wheals, a drop of blood frequently exuding from the puncture. In badly-infested forest a person sitting with a bare back and allowing the flies to do as they liked would probably be bitten once a minute at the very least.

It is the accepted belief of the Lumbwa and Kisii amongst whom I moved, that a disease is caused by the bites of these flies, the chief symptom being that the skin is in folds (Plate vii, fig. 1). It would seem that these folds appear first on the small of the back, but sometimes the skin higher up the back, and more rarely that of the front and sides of the body was seen to be affected in the same way, while occasionally, though this was only so with elderly people, the condition would extend to the arms and legs. Sometimes the skin was spotty, as shown in the photograph, and occasional cases were shown to me as *Simulium* disease in which spots, but no folding, were present. People with the affection scratch themselves a great deal.

Many of the affected people that I saw were able to carry on their usual activities, but some looked to be in quite a feeble condition. I asked one young man if he

could work properly, and those present laughed at my putting such a question to him. One man, the one shown in the photograph, I spoke of as " elder," and was told that he looked like an elder because of the disease, but was really only a " warrior."

Poor sight, or even blindness, is stated by the Lumbwa to be caused by the disease occasionally, but two people with the skin affection who had bad sight looked to me to be suffering from cataract.

The youngest person with the skin affection that I saw was a boy perhaps sixteen years old, but I was told that quite small children sometimes had it. Young people may recover from the disease, and I met three people who said they had done so; one of them, now an elder, said he had been ill for five years, and recovered ten years ago. With old people, I gathered, the condition always persists until death. Some people told me that they had had the disease for thirty years or more. It seems unlikely that the disease is the cause of death.

While the Lumbwa are convinced that this disease is caused by the bites of *Simulium*, they do not believe that it can be caused by a single bite or by only a few bites. I was told repeatedly that a person living a short time, say a fortnight, in badly infested country, would not get the disease, and people that I met have lived there much longer than that without contracting it. Again, I was told that while the disease could be contracted by herding animals in infested country day after day, it would be safe for a person to herd them there occasionally. The Lumbwa have no hesitation in going into infested country now and again to hunt, pick vegetables, or search for honey, and a very well-marked track runs right through the forest between the well-inhabited districts to the north and to the south of the infested forest on both sides of the Chemosit. And further, just away from the edge of infested forest, and in country where I took *Simulium* in small numbers, many Lumbwa were living, and considered themselves to be running only very slight risk of getting the disease. *Simulium*, the Lumbwa told me, does not enter houses.

Part of this slightly infested area adjacent to badly infested forest, the Lumbwa told me, they had cleared of thick forest, thus, they said, themselves converting it from unsafe into reasonably safe country. Another obvious way of avoiding the bites of the fly is the wearing of European clothes. I was scarcely bitten at all myself while moving in infested country for three weeks.

The total number of people that I saw who were said to have the disease at the time of my visit, not counting one Kisii, who possibly had the disease and who will be mentioned again shortly, was twenty-three. Seven other cases I heard of, but did not see, and probably some others exist. Of these twenty-three people, twelve were male and eleven female. Roughly speaking, eleven were young and twelve old. Of the twenty-three, eight were living in the forest at the time of my visit and at least six had lived there previously, making their homes elsewhere after getting the disease. The remainder had lived near to infested forest and had often gone into the forest. I was told that cases of this disease were not to be found in country away from the vicinity of infested forest. It was said that if a person with the disease attempted to settle in country other than adjacent to the infested forest, he would not be allowed to do so by the other inhabitants.

The one apparent exception which I came across, to the coincidence of distribution of the disease and *Simulium*, was a Kisii elder whose skin showed both folds and spots, but who was stated never to have lived in infested country.

Special reference must be made to two settlements in clear spaces in the infested forest, areas in which the fly could be found in fair numbers, and both surrounded by heavily infested forest, where I inquired, as far as I was able, after the health of those who were living there. There may have been other people that I did not see or hear about, but eight adults that I saw who had lived there for more than two years all had the disease, though one other old resident, a man that I did not succeed in

seeing, was stated probably not to have the disease. Six other adults who had lived there from a few weeks to two years were healthy. A number of children, too, some of whom had lived there all their lives, and might be as old as ten, were all free from the disease; they do not go into the forest nearly as often as grown-up people.

These facts, therefore, do indicate coincidence of distribution of the disease and *Simulium*.

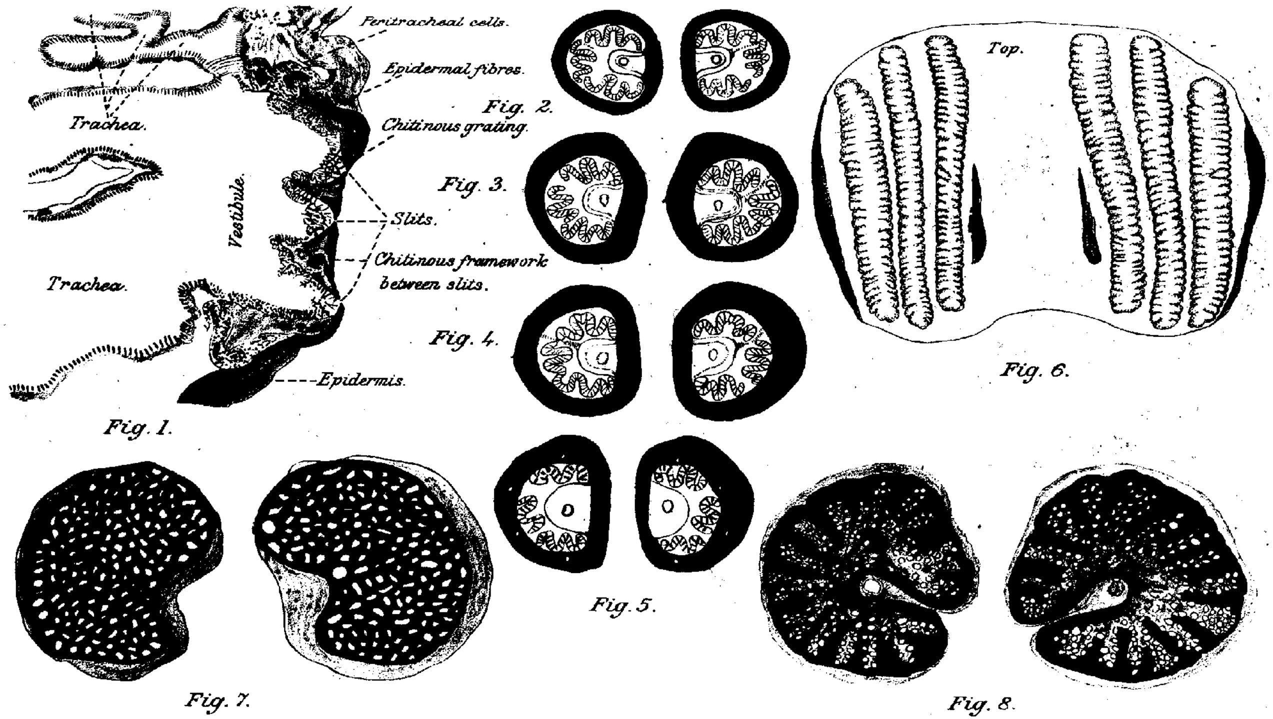
One piece of tribal history that I learnt from both the Lumbwa and Kisii throws light on the way in which *Simulium* is regarded by these two peoples. Formerly the country badly infested with *Simulium*, which is now in the Lumbwa Reserve, was occupied in its western part by the Kisii, the eastern part being left uninhabited out of mutual fear, for in those days the relations between the two tribes were by no means peaceful. Some time before the area came under British influence, possibly, though such information given by natives must be considered of doubtful accuracy, about thirty years prior to the present day, the Lumbwa succeeded in driving out the Kisii from the infested country, where they proceeded to settle, and established themselves, too, on the left bank of the Kipsoni and Sondo, but these Lumbwa were moved back across the river by the British Government.

I had a lengthy conversation with some of the Kisii, now old men, but warriors at the time of the war, who had formerly lived in the infested country. They told me that they knew the fly and the disease and believed the one to be the cause of the other. The Kisii had not hesitated to live in that country on account of the disease. Only a few of their people, they said, had had the disease. The land, they said, and the Lumbwa had told me the same, was excellent for crops and the grazing good. Wishing to know how seriously they regarded the disease, I asked them if they would go back to the *Simulium* country if they could. They replied, " Certainly," and asked if I had been sent to arrange for their return.

After that war the Lumbwa settled in the conquered country in considerable numbers, but very soon found they were getting the disease, when the great majority left the district. A few of the Lumbwa living in infested country and having the disease were amongst the original settlers and a few more have settled there more recently, but the total number of inhabitants, in an area of perhaps 20,000 acres, is small in the extreme.

I obtained blood-slides from three Lumbwa men who had lived in the infested country ever since it had become Lumbwa territory, and said they had had the disease for about thirty years. These slides Dr. Clearkin, Acting Senior Bacteriologist, afterwards kindly examined, finding about 20 per cent. of eosinophilia in the blood from each of the three individuals.

Dr. Clearkin hopes to find an opportunity of visiting the Lumbwa country to investigate the disease. The District Commissioner has tried to persuade some of the Lumbwa having the disease to come to Nairobi in order to be examined, but they have declined to leave their Reserve.



Huth, London.

SPIRACLES OF LARVAE OF MYIASIS-PRODUCING FLIES.

Fig. 9.

Fig. 10.

Fig. 11

Fig. 12.

Fig. 13.

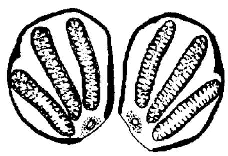


Fig. 14.

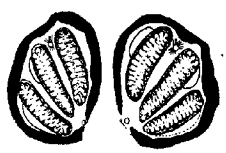


Fig. 15.

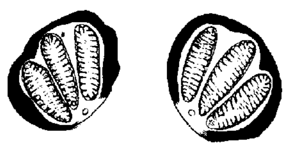


Fig. 16.

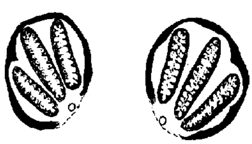


Fig. 17.

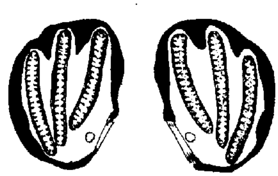


Fig. 18.

Huth, London.

SPIRACLES OF LARVAE OF MYIASIS-PRODUCING FLIES.

NOTES ON THE MYIASIS-PRODUCING DIPTERA OF MAN AND ANIMALS.

By Major W. S. PATTON, M.B., F.E.S., I.M.S. (rtd.),

Lecturer on Entomology and Parasitology, Edinburgh University.

(PLATES V & VI.)

Myiasis has been defined by Austen as follows :—" There remains yet a third category of flies, chiefly belonging to the great Family Muscidae, the larval stage of which is sometimes actually passed in the living human body, the presence of the larvae in the various organs and tissues, and the disorders or destruction of tissue caused thereby, being comprehensively known as Myiasis." It will be noted that this definition only refers to the larval stages of flies, but as the eggs, and in one case at least, pupae and adults, may be found in the human body, and as myiasis is a common condition in many animals, the definition may now be amplified as follows :—The condition or conditions, resulting from the invasion of the tissues and organs of man and other animals by all the stages of the Diptera.

In the latest edition of Castellani and Chalmer's "Manual of Tropical Medicine" (1919) species of flies belonging to no less than ten families have been incriminated as causing myiasis in man ; there is very little doubt, however, that the identification of some of the species is more than doubtful. These lists do not even include the most important myiasis-producing Calliphorine of Africa, *Chrysomyia bezziana*, Vill., so that the information given on this subject must be considered very incomplete. This is chiefly due to the fact that it is difficult to breed the flies from larvae recovered from cases of myiasis, in order to be sure of the identity of the species, and unfortunately in most cases identification of species by larvae alone is not yet possible. Although specimens of larvae are doubtless plentiful in museums and private collections, their respective adults, accurately identified, are, on the other hand, scarce.

Quite recently I undertook an inquiry into the larvae of the myiasis-producing Diptera of India in order to discover to what species of flies they belonged. Through the kindness of the Indian Research Fund Association I was able to issue a printed appeal, with detailed instructions for collecting living larvae, to every medical and veterinary officer in India, Burma, Assam and Ceylon, and in a very short time large numbers of living larvae and puparia were received from all over this area, and hundreds of flies were bred out and accurately identified. The results of this inquiry have demonstrated how little we know of the Indian species whose larvae cause myiasis in man and animals. The following species were found to be those which usually cause myiasis in man and animals in India :—

(1). *Chrysomyia (Pycnosoma) bezziana*, Vill.—This proves to be the common myiasis-producing Calliphorine of India and adjacent parts. Its larvae cause rhinal, oral, ocular, aural, vaginal and cutaneous myiasis in man and animals, but its larvae never cause intestinal myiasis.

(2). *Chrysomyia megacephala*, Fabr. (*dux*, Esch.) and *Lucilia argyricephala*, Fabr. (*serenissima*, Macq).—The larvae of both these species may be occasionally found in cases of myiasis in animals.

(3). *Sarcophaga* sp. incert.—This species, which it has not been possible to identify, as the larvae were sent to me preserved in spirit, occasionally causes cutaneous and intestinal myiasis in man. In the former cases the destruction of the tissues is very extensive.

(4). *Aphiochaeta xanthina*, Speiser (*ferruginea*, Brunetti), and *A. rufipes*, Meig.—These two Phorids commonly cause tissue and intestinal myiasis in man and animals in their larval stages.

During the course of this inquiry, which extended over more than a year, I gained a large amount of valuable information on such points as, how best to breed these flies from their larvae, how to preserve and send the larvae for further study and, most important of all, how to set about identifying the larvae and adults of blowflies in general, and the myiasis-producing species in particular. It is with the object of extending the inquiry to the study of the myiasis-producing flies from other parts of the world, particularly from Malaya, the Dutch East Indies, China, Japan, Australia and Tropical America, that I propose recording my notes in this paper. Although much valuable work has been done on the myiasis-producing Diptera of Africa by Rodhain, Bequaert, Roubaud and others, our information regarding the CALLIPHORINAE which parasitise man in their larval stages is still very imperfect. For instance, it is not known whether *Chrysomyia bezziana* deposits its eggs in human tissues in Africa, though its larvae are extremely common in human tissues in India. I would therefore ask all those who may have opportunities of collecting such material from man and animals to forward it to Dr. Guy A. K. Marshall, C.M.G., Director of the Imperial Bureau of Entomology, British Museum (Natural History), Cromwell Road, London, S.W. 7., who has kindly consented to receive it and forward it to me for further study. The results will be published from time to time in this Bulletin. I may say that as the identity and correct names of many of the common blowflies are at present hopelessly confused, I have decided to extend this study to the CALLIPHORINAE in general. Specimens of any blowflies and their larvae, particularly first stage larvae, and any of the larvae and adults of the OESTRIDAE will be most welcome. Most of the Indian material has already been collected, and is now being studied; material from the areas mentioned above would be of great value for comparative study. Those who wish to help in this inquiry will find full details of how to collect and breed blowflies in general, and the myiasis-producing species in particular, in these notes. I shall be glad to correspond with any observer who would like any further information on this subject.

The Classification of Myiasis-producing Diptera.

A reference to the recent literature on this subject shows that the myiasis-producing Diptera are mainly grouped according to the tissues or organs in which their larvae are found, so that we have such species as cause rhinal, oral, aural, ocular, tissue, and cavity myiasis. But such a Calliphorine as *Chrysomyia bezziana* will deposit its eggs in any of these organs or tissues, so that following this method of classification it would have to be placed in several of the groups.

Recently Bishopp has contributed a valuable article on this subject, grouping the species according to the methods of attack, his groups are as follows:—

(1). *Tissue-destroying forms.*—In this group are included those species whose larvae attack living animals secondarily, mainly breeding in the bodies of dead animals. Bishopp rightly places *Cochliomyia* (*Chrysomyia*) *macellaria*, the well-known screw-worm fly of Tropical America in this group, also such species as *Lucilia sericata*, and species of *Sarcophaga*. *Chrysomyia bezziana* would also have to be placed in this group, for its larvae are true tissue-destroyers, as anyone who has seen a scalp wound infested with its larvae will know. But this Calliphorine cannot be placed in the same group as *Cochliomyia macellaria*, *Lucilia sericata* and species of *Sarcophaga*, for the simple reason that it never breeds in dead tissues; it is a true specific myiasis-producing species, and the only known metallic Calliphorine which has this habit.

(2). *Subdermal migratory forms.*—Species, the larvae of which are true parasites of man and animals during the greater part of their lives, living beneath the skin,

and in the subcutaneous tissues; *Dermatobia hominis*, *Hypoderma bovis* and *Cordylobia anthropophaga* are good examples. *Chrysomyia bezziana* must also be placed in this group, for its larvae are true dermal parasites of man. I have had examples of its larvae sent me from such small skin punctures as are made in boring the lobes of the ears for ear-rings, and in small cuts on the skin. The only difference between a case of myiasis caused by the larvae of *Chrysomyia bezziana* and that of *Cordylobia anthropophaga* is that, in the former, it is a massed infection, while in that of the latter it is only one larva which causes the myiasis. In the former the tissues rapidly break down and suppurate, while in the latter they do not. Both are specific myiasis-producing Diptera.

(3). *Larvae infesting the intestinal and urogenital tracts.*—The larvae of these species feed, to a lesser or greater extent, on the food contained in these organs, especially in the gastro-intestinal tract. In this group Bishopp includes those species whose larvae accidentally find their way into the intestinal tract, such as the larvae of *Fannia canicularis* and those of many species of *Sarcophaga*, and those Oestridae whose larvae live in the intestinal tract of animals. I should like to point out that two categories are here involved; in the one case, the larvae only accidentally pass into the gastro-intestinal tract, the species concerned normally breeding outside the human body, whereas in the case of the Oestridae mentioned, the larvae can *only* live in special parts of the alimentary tract. Species with such distinct habits cannot be placed in the same group.

(4). *Forms infesting the head passages.*—In this group Bishopp includes those true parasites of man and animals, the larvae of which live in the nose and its accessory sinuses, the throat, etc. Here again, this group would have to include *Chrysomyia bezziana*, for its larvae also live in the nose and accessory sinuses, and are true human and animal parasites. In the one case the tissue destruction is not great, whereas in the other it is often extensive.

(5). *Blood-sucking forms.*—In this group Bishopp includes those species whose larvae are blood-suckers. Blood-sucking can, however, hardly be considered a form of myiasis, for then we would have to include in this group all the blood-sucking Diptera.

I have said enough to show that the various methods of grouping the myiasis-producing Diptera according to the tissues or organs attacked, or the methods of attack, are not satisfactory. I am of opinion that the subject is best considered from the standpoint of the habits of the flies themselves, which then naturally fall into three groups as follows:—

(1). Specific myiasis-producing Diptera.

(2). Semi-specific myiasis-producing Diptera.

(3). Accidental myiasis-producing Diptera.

I will now give a few notes on the adults, hosts, geographical distribution, etc., of the species belonging to the various groups, reserving the notes on all the larvae until their identification is dealt with.

Specific Myiasis-producing Diptera.

In this group I include all those Diptera whose larvae are found only in living tissues, the flies selecting a number of tissues or organs, or one particular organ, depending on the species, in which or near which to lay their eggs or deposit their larvae. The following species are included in this group:—*Chrysomyia bezziana*, *Cordylobia anthropophaga*, *C. rodhaini*, *Wohlfahrtia magnifica*, and all the Oestridae.

Chrysomyia bezziana, Villeneuve.—As I have mentioned above, this species is the specific myiasis-producing Calliphorine of India, Burma, Assam, Ceylon and Africa. Its larvae are commonly found in the nose and accessory sinuses, the mouth,

ear, eye and vagina, and in sores, cuts, wounds and abscesses, in man and animals. As a result of the enquiry made in India, I received the larvae of this species from more than 170 cases of human and animal myiasis; not a single larva was sent from the intestinal tract. As this fly breeds only in living tissues it is rarely seen in nature, for it does not frequent places where most other blowflies may be seen, such as food stalls, refuse heaps, latrines, and about the bodies of dead animals. The female fly is attracted by any offensive discharge, and will then lay her eggs in a mass, varying in number from 380 to 500, on or near the tissues from which the discharge comes. A sore, wound, or a diseased organ, such as a nose from which there is an offensive discharge, is therefore a necessity. The larvae rapidly reach maturity, owing to the high body temperature and rich food, and when mature crawl out and pupate in the ground. It is very probable that the adults are flower-feeders, and that as the mature larva stores up a large amount of food in its fat-body, there is sufficient nutriment for the eggs to ripen, as in the case of the OESTRIDAE.

Chrysomyia bezziana is a well-known pest in Africa, where it has been recorded by Rovere, Bouet, Roubaud and Joyeux from the Belgian Congo, the Upper Ivory Coast and French Upper Guinea; by Jack from Rhodesia; and by Aders from Zanzibar. Curiously enough, in Africa its larvae have been recorded only from the tissues of the larger animals, chiefly cattle; so far as I am aware, they have never been found in human tissues.

In India the female *C. bezziana* may be readily confused with the female of *Chrysomyia megacephala*, F. (*dux*, Esch.); both species have yellow cheeks. In order to distinguish them with any certainty, it is necessary to examine the front and to note the following points :—The front of the female *megacephala* is more than one-third the width of the whole head, that of *bezziana* is distinctly less than one-third. The frontal stripe of *megacephala* is wider than that of *bezziana*, the sides appearing slightly convex along their outer margins; in *bezziana* the stripe is slightly browner and the sides are almost straight. The para-frontals in *megacephala* are wider and of a greyish yellow colour, those of *bezziana* being much more silvery. The ocular margin of *megacephala* is slightly concave, and the lower margin of the eye rounder than in *bezziana*. The vertical bristles of *megacephala* are better developed than those of *bezziana*. Lastly, and this is perhaps the most valuable distinguishing character, the squamae of *megacephala* are of a dirty yellow colour, while those of *bezziana* are waxy white; in both they are covered with dark hairs.

The male *megacephala* can be readily distinguished from the male *bezziana* by its bright red eyes, and the area of large lenses occupying about the upper third and surrounded by smaller ones. In the male *bezziana* the eyes are brown, and the lenses are small and all of about the same size.

Although originally described from Guinea, I have not seen any specimens of *megacephala* from any part of Africa, so I am unable to say whether it occurs there. It is plentiful in the bazaar at Port Said, and one would expect it to occur in Egypt at least. It is, however, present in the Australian region.

There is no other Calliphorine which may be confused with *bezziana*, unless it be *Chrysomyia flaviceps*. I have not been able to identify this species with certainty, and whenever this name is used by writers in India, *Chrysomyia megacephala* is meant, so that there is some confusion regarding it; it is probably a synonym for *megacephala*.

There is much which has yet to be discovered in connection with the distribution and life-history of *Chrysomyia bezziana*. For instance, we do not know the limits of its eastern distribution. Does it occur in Malaya, the Dutch East Indies, China and Japan? I hope that those who have opportunities of collecting larvae from living tissues, either of man or animals, in any of the areas mentioned above, will do so, and send me the larvae for identification.

Cordylobia anthropophaga, Blanchard.—This is the most important specific myiasis-producing Calliphorine of Africa, where it is widely distributed, ranging from the Bahr-el-Ghazal Province of the Anglo-Egyptian Sudan in the east, and the northern limits of Senegal in the west, to Natal in the south. The most complete account of its life-history and habits will be found in Roubaud's, " Etudes sur la Faune parasitaire de l'Afrique Occidentale Française," Part 1. In its larval stage it is essentially a parasite of dogs, but is also found in a number of other domestic animals. The female fly lays her eggs in dust, sand, earth, etc., where the host is accustomed to lie. The first stage larva, which is extremely small but very active, on finding itself in the neighbourhood of the skin of a host, attaches itself to it, and then bores its way into the epidermis. It now rapidly passes through its moults, and the third stage larva, which is very distinct from the first instar in external structure, as is the case in many of the allied CALLIPHORINAE and the OESTRIDAE, forms a palpable tumour below the skin, its posterior extremity being in the vicinity of the opening into the tumour, so that air can be taken in through the posterior stigmata. These tumours never suppurate in the ordinary course of events, but may do so, if for any reason the larva dies.

Cordylobia (Stasisia) rodhaini, Ged.—This Calliphorine is the only other species whose larvae are known to cause cutaneous myiasis in Africa. It appears to be restricted to the damp forest regions of the Congo, and its larvae are normally found under the skin of the duikers, such as the bay duiker, *Cephalophus dorsalis*, and the common duiker, *Cephalophus grimmi*, as well in the large rodent, *Cricetomys gambianus*; man is only accidentally infested. Thin-skinned animals are the only ones attacked, and the immobility of the host at the time of the hatching of the larva from the egg is a necessity. As in the case of *Cordylobia anthropophaga*, the eggs are laid in damp earth, particularly where the hosts are accustomed to lie, and where urine has been voided. The first-stage larva soon makes its way into the epidermis and rapidly passes through its moults, reaching maturity in fifteen days.

A comparative study of the various larval instars with those of other CALLIPHORINAE would be of great interest, and I trust that those who have opportunities of obtaining them will send me any specimens.

Wohlfahrtia magnifica, Schiner.—This species is the only European specific myiasis-producing fly, and belongs to the family SARCOPHAGIDAE, or Flesh Flies. All the species of *Wohlfahrtia* can be distinguished from those of *Sarcophaga* by the well-defined round spots on the abdomen, instead of the shimmering chequered marks, so characteristic of all the species of *Sarcophaga*. The species of the allied genus *Sarcophila* also have round spots on the abdomen, but the arista is only plumose towards the base, while in the species of *Wohlfahrtia* the arista is plumed for some distance. *Wohlfahrtia magnifica* deposits its larvae in cuts, sores, wounds, and at the entrance to the nostrils and vagina, and on the eyelids, the fly being attracted by an offensive discharge from such tissues or organs. It is widely distributed in Southern Russia, Asia Minor and Egypt, where it is a serious pest to man and animals. Portchinsky has made an exhaustive study of its life-history and habits, as well as those of some allied species. None of the other species of *Wohlfahrtia* appear to be specific myiasis-producing flies.

Flies of the Family Oestridae.

In this family are included a large number of highly specialised flies, whose larvae can only reach maturity in certain tissues and organs of special animals and their near allies. For example, the larvae of the horse bots (*Gasterophilus*) and those of the elephant bots (*Cobboldia*) can only live in the stomachs and duodenum of the EQUIDAE and the ELEPHANTIDAE, attaching themselves deeply by their mandibular hooks to the mucous membrane of the alimentary tract. The exact nature

of the food of such larvae is not clearly understood, but from a large number of dissections and examinations of the mid-guts of the larvae of the sheep nose-bot (*Oestrus ovis*), I was unable to confirm Brauer's suggestion that these Oestrid larvae are blood-suckers. The contents of the mid-guts of larvae recently removed from their hosts clearly suggested that they had fed on serous exudations, most probably resulting from the irritation produced by the minute, but deep, punctures made by their mandibular hooks in the mucous membrane. I had several opportunities of examining the naso-pharynx of dromedaries heavily infested with the larvae of their nose-bot, *Cephalopsis titillator*, and there was no doubt whatever that the mucous membrane was in a pathological condition, and in life would exude much mucus.

The entire larval stage of the OESTRIDAE is a long one, and is chiefly passed in the third stage, but the adults, on the other hand, are short-lived. Sufficient food is taken in by the third stage larva, and stored up in the form of fat-body, so that when the adults hatch out, particularly the female, there is ample nourishment for the development of the eggs, and even for the hatching of the first stage larvae *in utero*. The adults therefore do not feed, and as a result their mouth-parts have atrophied for want of use. There can be very little doubt that when such larvae are in large numbers, the host suffers, and may, as I will point out further on, even die as a result of a massed infestation.

The OESTRIDAE are at present grouped in a number of subfamilies according to the structure of the third stage larva, and that of the adults. A few notes on the species belonging to the various subfamilies may be useful to those who have opportunities of collecting any of these flies, either as larvae or as adults. For much of the information given below I am indebted to the exhaustive works of Rodhain and Bequaert, as well as to those of Gedoelst and Roubaud.

1. Subfamily GASTEROPHILINAE.

All the species of this homogeneous group are myiasis-producers in their larval stages, the larvae living in the stomach, and in one case in the duodenum, of the horse and its allies. These larvae have occasionally been found in the stomachs of certain carnivores which had fed on dead horses, donkeys, etc., but this infestation is only accidental. In Russia some of the species now and then deposit their eggs on the hair of the human face, such as the eyebrows, and the first stage larvae then penetrate the skin, and cause the so-called "creeping myiasis," the little larva burrowing along under the skin, evidently endeavouring to find its way into the alimentary tract; they never, however, reach the stomach, and thus do not become mature. As would be expected, such larvae only belong to those species of *Gasterophilus* whose larvae normally penetrate the skin of the horse, after hatching out of the egg, and do not depend on moisture and friction to help them to leave the egg, and enter the mouth. *Gasterophilus veterinus* (*nasalis*) and *G. haemorrhoidalis* are the two species whose larvae usually cause this form of myiasis. *Gasterophilus intestinalis*, on the other hand, cannot do so, as its larvae can only hatch out of the egg with the aid of friction and moisture.

The following species of *Gasterophilus* are known in their larval and adult stages:—

Gasterophilus intestinalis, De Geer (*equi*, Clark). This is the common horse bot of Europe and North America; it has also been recorded from many parts of Africa, such as South Africa, the Belgian Congo, Senegal, French Guinea, the Gold Coast, etc. It is also found in Australia and New Zealand. In India and Mesopotamia there is a variety, *bengalensis*, Macq., which is very common in the north of India. Another variety, *asininus*, Br., is recorded from the Anglo-Egyptian Sudan, its larvae being parasitic in the stomach of the donkey.

Gasterophilus haemorrhoidalis, L.—This is also a European and North American species, and Gedoelst records it from the Belgian Congo. Its larvae are parasitic in the stomach of the horse.

Gasterophilus veterinus, Clark (*nasalis*, L.).—This species is found throughout Europe, North America, Australia, French Guinea and Mesopotamia. Its eggs are always attached to the hairs between the rami of the lower jaw, the fly darting between the legs and striking the space, each time depositing an egg. Townsend states that the eggs actually pierce the skin, but it is only necessary to examine the ovipositor to see that this is an impossibility.

Gasterophilus pecorum, F.—This is the common horse bot of Russia, Hungary and Italy; it has also been recorded from South and West Africa. A variety, *zebrae*, Rodh. & Beq., is parasitic in its larval stage in the stomach of the zebra, *Equus böhmi*, in East Africa.

The following species are only known in their adult stages:—

Gasterophilus flavipes, Oliv.—This species is recorded from the Mediterranean region, Spain, North Africa, Asia Minor and the Anglo-Egyptian Sudan. Its larvae are believed to be parasitic in the stomach of the ass.

Gasterophilus nigricollis, Lw.—This species is only known from Bessarabia.

Gasterophilus lativentris, Brauer.—From Courland.

Gasterophilus magnicornis, Bezzi.—This species is found in the Italian Somaliland and is probably identical with *G. intestinalis* var. *bengalensis*, judging from the description. Its larvae are believed to be parasitic in the stomach of the horse and ass.

The following species are only known as larvae:—

Gasterophilus gedoelsti, Rodh. & Beq.—From East Africa; the larvae are parasitic in the stomach of the zebra, *E. böhmi*.

Gasterophilus ternicinctus, Ged.—From Nyasaland; the larvae are parasitic in the stomach of the zebra, *E. burchelli crawshayi*.

There are several other doubtful larvae of *Gasterophilus* that have been described. There can, I think, be very little doubt that when a critical examination is made of fresh material of the larvae and adults of the species of this subfamily, this long list of species will be reduced.

Rodhain and Bequaert place in this subfamily the bot-flies of the rhinoceros, *Gyrostigma*, of which there are three, possibly four, good species, the adults of only two being known.

Gyrostigma pavesii, Corti.—This species, the adults of which are known, is parasitic in its larval stage in the stomach of the African black rhinoceros, *R. bicornis*, which is found from Abyssinia and Somaliland, through East and Central Africa, in suitable localities down to the Cape. It is also found in the stomach of the white or Burchell's rhinoceros, *R. simus cottoni*, which is found in South and South-East Africa, as far north as the Zambesi, and again in equatorial Africa at Lado, just north of the Equator.

Gyrostigma meruenis, Sjöstedt.—The larvae of this species are parasitic in the stomach of the black rhinoceros, *R. bicornis*.

Gyrostigma conjugens, Enderlein.—The larvae of this species are also parasitic in the stomach of the same rhinoceros.

Gyrostigma sumatrensis, Brauer.—The larvae of this species were recovered from the stomach of the Sumatran rhinoceros, *R. sumatrensis*, which is found in Assam and Siam, the Malay Peninsula, Sumatra and Borneo, and also from the stomach of the Assam local race, *R. sumatrensis lasiotis*.

According to Rodhain and Bequaert the eggs of *G. pavesii* are laid on the skin of the ears, neck and shoulders of the host, so that it is very probable that the larvae are only able to leave the eggs when, as in the case of *Gasterophilus intestinalis*, they are licked; on reaching the mouth they can then pass down into the stomach.

2. Subfamily OESTRINAE.

This subfamily has recently been monographed by Rodhain and Bequaert, who recognise five genera. The larvae of *Oestrus, Gedoelstia* and *Kirkioestrus* are parasitic in the frontal and neighbouring sinuses of ruminants, those of *Rhinoestrus* in the same sinuses of equines, pigs and the hippopotamus; and the larvae of *Cephalopsis* (*Cephalomyia*) in the naso-pharynx of the dromedary and camel.

The following key is taken from Rodhain and Bequaert, and may be found useful in distinguishing the genera :—

1 (*a*) Wings with a section of the apical transverse nerve (the outer section of the 4th nerve?) turned up almost vertically to the long diameter of the wing. Long veins 2, 3 and 4 almost of the same length, ending before the last quarter of the wing. Transverse marginal vein ending before the middle of the first posterior marginal cell. Antennal pits separated on the face by a large flattened border .. .. *Cephalopsis.*

1 (*b*) Transverse apical vein not vertical to the long diameter of the wing. Transverse marginal vein ends in the middle of first posterior cell or thereabouts .. .. 2.

2 (*a*) Rudiments of proboscis elongated, prolonged in front towards the end between the palps, the extremity divided into three long cushions which represent the labella and the rudimentary lips. Antennal pits more or less confluent, but separated by a flattened round ridge. Body thick-set, covered with large papules. Abdomen short, cylindrical, almost without pilosity, Legs short and slender. Apical transverse nerve without an appendix .. .. *Rhinoestrus.*

2 (*b*) Rudiments of proboscis conical, not extending beyond the palps at the base, and without traces of labellae. Venter and posterior extremity of abdomen covered with long and fine pilosity .. .. .. 3.

3 (*a*) Antennal pits confluent, not separated by a median flattened edge. Abdomen elongated, slightly flattened dorso-ventrally, contracted and bent towards the base in front. Body without papules and gross sculpture, but with short abundant pilosity, especially on abdomen; relatively long and robust. Apical transverse vein with an appendix .. .. *Kirkioestrus.*

3 (*b*) Abdomen squat, cylindrical, not flattened dorso-ventrally, not recurved towards the front. Body grossly sculptured, either with tufts or papules, less on thorax. Pilosity not very abundant. Short and slender legs. Apical transverse vein without an appendix ..

4 (*a*) Antennal pits not confluent, separated on face by a large flattened edge. Abdomen with denticulated tufts on dorsal surface of segments 2, 3 and 4 .. .. *Gedoelstia.*

4 (*b*) Antennal pits more or less confluent, not separated by a large flattened ridge. Abdomen without any tufts on the dorsal surface. .. *Oestrus.*

The following notes on the species give the hosts in which the larvae are found :—

Oestrus ovis, L.—The common sheep and goat bot, found wherever the hosts occur. Its larvae are parasitic in the nasal passages, and are often present in large numbers. Although the larvae are easily obtained, the adults are seldom seen. The first stage larva has been recorded from man in Russia, Italy, and Algeria, in the conjunctiva, mouth and nasal cavities; but it is more than probable that in the majority of these cases they were not those of *O. ovis* but of *Rhinoestrus purpureus.*

Oestrus variolus, Lw.—This is the common bot of the western hartebeest, *Bubalis major*, and Jackson's race of the Lelwel hartebeest; its larvae are found in the nasal passages of a large percentage of these antelopes.

Oestrus aureo-argentatus, Rodh. & Beq.—The larvae of this species are common in the nasal passages of the roan antelope, *Hippotragus equinus*, and its local races, and in the western and Jackson's hartebeest.

Oestrus macdonaldi, Ged.—The larvae of this somewhat rare species have so far only been found in the nasal passages of Lichtenstein's hartebeest, *Bubalis lichtensteini*.

Oestrus interruptus, Ged.—The mature larva of this species is parasitic in the nasal passages of Coke's hartebeest, *Bubalis cokei*, the brindled gnu, or blue wildebeest, *Connochoetes taurinus johnstoni*, and the bastard hartebeest, *Damaliscus lunatus*.

Oestrus disjunctus, Ged.—The larva of this species is parasitic in the nasal passages of the bastard hartebeest, and the roan antelope.

Oestrus compositus, Ged.—The larva of this species is found in the nasal passages of Lichtenstein's hartebeest.

Rhinoestrus purpureus, Brauer.—This species, the larvae of which are parasitic in the nasal passages of the horse, the mule and zebra in Europe, Asia Minor, Palestine and Africa, is an important Oestrid, as the female fly has the habit of depositing its larvae in, or near, the human eye, and may thus lead to the loss of an eye. It is probably the larvae of this species that has been confused with that of *Oestrus ovis* in those cases in which the latter has been recorded from the human face.

Rhinoestrus phacochoeri, Rodh. & Beq.—The larva of this rare species is found in the nasal sinuses of the warthog, *Phacochoerus aethiopicus*, in the Belgian Congo; the adult fly is not known.

Rhinoestrus nivarleti, Rodh. & Beq.—The larvae of this species are parasitic in the nasal sinuses of the red river-hog, *Potomochoerus porcus*, in the Belgian Congo and adjacent parts of West Africa; the adult fly is not known.

Rhinoestrus hippopotami, Grünberg.—The larvae of this interesting Oestrid, the only species known from the hippopotamus, is parasitic in its nasal cavities.

Gedoelstia cristata, Rodh. & Beq.—The larvae of this species are found in the nasal cavities of various antelopes such as Lichtenstein's hartebeest, the western hartebeest, Jackson's variety of the Lelwel hartebeest, the white-bearded race of the blue wildebeest, and the topi or variety of the Senegal hartebeest.

Gedoelstia hässleri, Ged.—The larvae of this species are parasitic in the nose and accessory sinuses of Lichtenstein's hartebeest and the bastard hartebeest.

Kirkioestrus surcoufi, Ged.—The larvae are parasitic in the nasal cavities of the western hartebeest, Jackson's hartebeest, and species of the lechwe in various parts of West Africa.

Kirkioestrus blanchardi, Ged.—Its larvae are parasitic in the nasal cavities of Lichtenstein's hartebeest in the basin of the Zambesi.

Kirkioestrus minutus, Rodh. & Beq.—The larvae of this species are parasitic in the nasal cavities of Jackson's hartebeest and the topi, in the Congo.

Cephalopsis titillator, Clark (*Cephalomyia maculata*, Macq.).—The larvae of this species, the only bot-fly of the CAMELIDAE, is parasitic in the naso-pharynx of the dromedary and the camel, wherever these animals are found.

3. Subfamily COBBOLDIINAE.

The stomach-bots of the Indian and African elephants are placed in this subfamily, and there seems little doubt that they are near allies of the equine stomach-bots, the GASTEROPHILINAE.

Cobboldia elephantis, Steel.—The larvae of this species are parasitic in the stomach of the Indian elephant. I have been told by those who have to do with the elephants kept by the Government of Madras, in various parts of South India, that this bot-fly is a serious pest. There seems little doubt that when the larvae are in large numbers in the stomachs of the elephants, especially the young animals, they suffer in health, often being on the sick list with digestive troubles, and are unable to work; and in bad infestations the young animals may even die. Mr. Chari, Veterinary Inspector, Mount Stuart, sent me a large number of third stage larvae of *C. elephantis* that were collected from the stomach of a calf elephant, which was so full of larvae that there was hardly any room for a pin to pass into it. The eggs are laid at the root of the tusk or trunk, and the larvae only hatch out when the eggs are moistened. I had a large number of these eggs collected about a month after they were laid, and as soon as they were placed in some water the young larvae immediately burst open the eggs and emerged; they are very active and can crawl considerable distances.

The African elephant is parasitised by the larvae of three species of *Cobboldia*. The larvae of *Cobboldia loxodontis*, Brauer, have been recorded from Uganda, the Belgian Congo, and the Ivory Coast, but its distribution is probably much wider; those of *C. chrysidiformis*, Rodh. & Beq., have so far only been found in the stomachs of elephants from the Belgian Congo; while those of *C. parumspinosa*, Ged., have been recorded only from the basin of the Zambesi.

4. Subfamily HYPODERMATINAE.

This subfamily contains all those OESTRIDAE whose larvae cause cutaneous myiasis in ruminants, chiefly cattle and antelopes. The following are the more important species:—

Hypoderma bovis, De Geer.—The larvae cause the well known warbles, which are common in the hides of cattle in Europe and North America. Captain Cross, C.V.D., has sent me what appear to be the larvae of this species from the skins of goats in the Punjab, a very large percentage of the animals being infested.

Hypoderma lineata, de Villers.—The larvae are also parasitic in the hides of cattle in Europe and North America, but are not so common as those of *H. bovis*. It is only recently that the method of infestation has been worked out in the case of *Hypoderma bovis* by Carpenter in Ireland, Gläser in Germany, and Hadwen in Canada. The females of these two species lay their eggs on the hairs of the legs of cattle, and the larvae on hatching out penetrate the skin adjacent to the hair, and then slowly migrate upwards until they reach the submucous coat of the oesophagus, resting there for some time in the second larval stage. Later they pass along the muscles of the back and eventually reach the back and sides of the animal, where they make a small opening in the skin. When mature they leave the skin and pupate in the ground.

Hypoderma diana, Brauer, and *H. actaeon*, Brauer.—The larvae of these two species are parasitic in the skins of the red deer in Germany and Britain.

Hypoderma silenus, Brauer, is parasitic in its larval stage in the skin of the ass in Egypt: *Hypoderma desertorum*, Brauer, is also found in Egypt, but its host is not known. *Hypoderma gazellae*, Ged., is parasitic in its larval stage in the skin of Grant's gazelle in East Africa. *Hypoderma corinnae*, Crivelli, in the skin of the Dorcas gazelle, *Gazella dorcas*.

Oedemagena.—This genus, which contains only one species, differs from *Hypoderma* in having small oval labella, which are absent in *Hypoderma*. *Oedemagena tarandi*, L., is parasitic in the hides of reindeer in Lapland and Norway.

5. Subfamily Cuterebrinae.

In this subfamily are placed a somewhat heterogeneous collection of genera and species, all the larvae of which are parasitic in the skin and subcutaneous tissues of small rodents, chiefly Muridae; they are only found in North and South America. Townsend raises the subfamily to a family, the Cuterebridae, and gives the following key to the genera :—

(1) No facial carina; antennal pit large and deep; antennae elongate .. 2.
Facial carina present; antennal pit small and shallow; antennae short 3.

(2) Epistoma rather broad, projected obliquely forward and downward between the peristomalia; arista thickly long-plumose to tip *Pseudogametes.*
Epistoma very narrow, projected straight downward between the peristomalia; arista with hairs on upper side only .. *Dermatobia.*

(3) Arista nude .. .. *Rogenhofera.*
Arista with hairs on upper side and on apical part of lower side .. 4.

(4) Antennal pit extended below in a tapering prolongation, the peristomalia converging obliquely and meeting near the lower end of carina .. .. *Cuterebra.*
Antennal pit circumscribed below, subcircular, the peristomalia parallel and closely approximated to the carina for about the lower half of its length .. .. *Bogeria.*

The following are the more important species :—

Pseudogametes hermanni, Br., and *P. semiatra*, Wied., from the subcutaneous tissues of Muridae in Brazil.

Dermatobia hominis, L.—The larvae of this species are chiefly found in the skin of cattle in tropical America and the neighbouring islands; man is seldom parasitised. It is now known that the female fly lays its eggs in small batches on the bodies of blood-sucking and sweat-loving insects, such as the Culicid, *Janthinosoma lutzi*, and species of *Anthomyia*, and the larvae hatch out when the egg-carrier visits the vertebrate host to feed, penetrating the skin and forming a local tumour.

Rogenhofera grandis, Guérin, *R. trigonocephala*, Br., and *R. dasypoda*, Br., from the skins of Muridae in Argentine and Brazil. *Cuterebra americana*, F., *C. cuniculi*, Clark, *C. analis*, Macq., *C. approximata*, Walk., *C. histrio*, Coq., *C. tenebrosa*, Coq., *C. atrox*, Clark, and *C. maculosa*, Knab, all from the skins of small rodents in North and Central America.

Cuterebra ephippium, Latr., larvae parasitic in the skins of Muridae in French Guiana, *C. patagona*, Guér., from Patagonia, *C. megastoma*, Br., from South America, *C. funebris* from Trinidad, *C. apicalis*, Macq., *C. cayennensis*, Macq., *C. rufiventris*, Macq., *C. nigrocincta*, Aust., *C. sarcophagoides*, Lutz, *C. nigricans*, Lutz, *C. infulata*, Lutz, and *C. schmalzi*, Lutz, from Brazil. *Bogeria emasculator*, Fitch, *B. grisea*, Coq., *B. buccata*, F., *B. fontenella*, Clark, *B. princeps*, Aust., *B. fasciata*, Swenk., *B. scudderi*, Towns., all from North and Central America.

From the studies of Hadwen, and Parker and Wells, it seems that these Cuterebrine bot-flies deposit their eggs on the hairs of their hosts, and that they are then licked off and enter the alimentary tract, later migrating outwards to the skin, where they cause dermal myiasis.

6. Subfamily Cephenomyinae.

In this subfamily are included a small number of Oestrids, the larvae of which are parasitic in the nose and accessory sinuses of the Cervidae and Bovidae and one species in the oesophagus of the African elephant. Most of the species are found in

Europe and in North and South America. As in the case of the OESTRINAE, the females are viviparous and deposit their larvae at the entrances of the nostrils, the larvae then migrating up into the frontal sinuses, and down, even into the oesophagus.

Cephenomyia auribarbis, Mg., is a common parasite in its larval stage in the red deer in Europe; the larvae of *C. ulrichi*, Br., in the elk; *C. trompe*, L., in the reindeer; *C. stimulator*, Clark, in the roe; and *C. abdominalis*, Aldrich, from the Adirondacks, New York. *C. pratti* is parasitic in its larval stage in the American elk, the mule deer, and several other deer in North America, *C. phobifer* is only known in its adult stage from North America, and *C. macrotis* has been recorded in its larval stage from the mule deer in North America.

Semi-specific Myiasis-producing Diptera.

In this group I include all those flies which, though normally breeding in the bodies of dead animals, and even in vegetable matter, will occasionally lay their eggs, or deposit their larvae, in the diseased tissues of man and animals. The female fly is in each case attracted by a foul discharge from a sore, wound or diseased organ, such as the nose or ear, or even in soiled wool. The following species belong to this group:—

Calliphora erythrocephala, Mg.
,, *vomitoria*, L.
,, *quadrimaculata*, Swed.
,, (*Anastellorrhina*) *augur*, L.
Cochliomyia (*Chrysomyia*) *macellaria*, L.
,, *viridula*, R.D.
Chrysomyia megacephala, F. (*dux*, Esch.).
,, *marginale*, Wied.
,, *albiceps*, Wied. (*rufifacies*, Guérin).
,, *varipes*, Macq.
Pollenia stygia, F.
Phormia regina, Mg.
Cynomyia cadaverina, R.D.
Lucilia sericata, Mg.
,, *caesar*, L.
,, *argyricephala*, F. (*serenissima*, Macq.).
,, *tasmaniensis*.
Sarcophaga ruficornis, F.
,, *chrysostoma*, Wied.
,, *plinthopyga*, Wied.
Aphiochaeta xanthina, Speiser.
,, *rufipes*, Mg.

A few notes on the above species may be useful.

Calliphora.—All the species belonging to this genus of blowflies are large robust insects of a dark blue colour, often with lighter patches on the abdomen. The palpi are nearly always reddish, the legs black, and the thorax adorned with large bristles. The females, which are oviparous, occasionally lay their eggs in living tissues of man and animals, though normally ovipositing in decaying animal matter; the habit of ovipositing in diseased tissues is not well established in the species of this genus.

Cochliomyia.—These blowflies can be distinguished at once from their Old World allies of the genus *Chrysomyia* (*Pycnosoma*) by the well-marked dark dorsal thoracic stripes. *C. macellaria*, the notorious screw-worm fly of tropical America, like its ally, *Chrysomyia bezziana*, will lay its eggs in any diseased tissues, but unlike it, will also breed freely in the bodies of dead animals, and even in decaying vegetable matter. Its control is therefore a much more hopeless task than that of *Chrysomyia*

bezziana. The larvae of *Cochliomyia viridula* are known to cause cutaneous myiasis in man and animals in British Guiana and Trinidad. Doubtless there are several other species of this genus in South America with like habits.

Chrysomyia (*Compsomyia, Pycnosoma*).—The blowflies of this genus are usually of a bluish green colour, and have well-marked horizontal bands on the hind borders of the abdominal segments. The thoracic bristles are reduced, the dorsal surface being covered instead with fine hairs. *Chrysomyia megacephala* is one of the species that occasionally deposits its eggs in the tissue of animals in India. It is very similar in general appearance to *Chrysomyia bezziana*, as pointed out above. *Chrysomyia marginale* is a common African species, and though mainly breeding in decomposing bodies of animals and birds, will occasionally lay its eggs in, or near, diseased tissues. *Chrysomyia albiceps* (*rufifacies*) is, according to Froggatt, a notorious sheep maggot fly in Australia, its larvae being found in company with those of two other blowflies, *Anastellorrhina augur* and *Pollenia stygia*. In India I have noted that the larvae of *albiceps* are entirely predaceous, feeding on the larvae of other CALLIPHORINAE, so that it seems possible that it lays its eggs in soiled wool in Australia, being attracted by the presence of other larvae; this point requires further investigation. *Chrysomyia varipes* is a smaller species with a somewhat similar larva; it also breeds in soiled sheep wool in Australia.

Anastellorrhina augur is a well-known sheep maggot fly in Australia. It is a large species, suggesting affinities with *Calliphora*. The larva, as I will point out further on, is very similar in structure to that of *Calliphora erythrocephala*.

Pollenia stygia (*villosa*) is another allied species, which is placed in this genus because of the fine yellow hairs on the sides of the thorax. It is a serious pest to farmers in Australia.

Phormia regina, though a common fly in Europe, is not, so far as I am aware, known to cause myiasis in animals. In America, however, it often lays its eggs in soiled wool and in wounds of sheep, particularly old suppurating wounds. Bishopp states that its larvae are often found in sheep with broken horns.

Cynomyia cadaverina very occasionally causes myiasis, more especially in very foul wounds on animals. It is, however, a regular breeder in decaying animal matter.

Lucilia.—The species of this genus of bright metallic green blowflies can be distinguished from the species of the genus *Chrysomyia* by noting that there are many strong bristles on the thorax, arranged in two parallel rows. *Lucilia sericata* is the most notorious species, for it regularly lays its eggs in the soiled wool and tissues of sheep in Europe, and more particularly in Scotland. It is also recorded from Australia as a sheep-maggot fly. *Lucilia caesar* only very occasionally lays its eggs in living tissues. *Lucilia argyricephala* is the common Oriental species and occasionally lays its eggs in the diseased tissues of animals. *Lucilia tasmaniensis* is said to be a myiasis-producing species in Tasmania.

Sarcophaga.—All the species of this cosmopolitan genus are very characteristic large grey flies with red eyes. Though easily recognizable generically the species are exceedingly difficult to determine. All are semi-specific myiasis-producing flies normally breeding in dead bodies and decomposing animal matter. In India there is, at least, one species which deposits its larvae in wounds, particularly those exuding very foul pus, and the larvae, owing to their large size, cause very extensive destruction, so that there can be no mistaking a case of myiasis caused by such larvae. This species is believed to be *ruficornis*, but this identification is not certain. I would particularly urge all those who have opportunities of collecting the larvae of species of *Sarcophaga* from cases of myiasis to breed out the flies, for it is only by doing this that we can be certain of the species and can then study its habits and distribution. *Sarcophaga lambens*, Wied., and *Sarcophaga pyophila*, Neiva, are recorded as causing myiasis in Central and South America. *Sarcophaga chrysostoma*, Wied., in British Guiana, and *S. plinthopyga*, Wied., are also notorious myiasis-producing species.

Aphiochaeta.—The species of this Phorid genus can be recognised by their peculiar habit of moving in a jerky manner, and by the structure of the antennae and the characteristic venation. *A. xanthina (ferruginea)* is a yellowish brown species, which is widely distributed in the tropics, and its larvae cause cutaneous myiasis in man and animals. *A. rufipes* is also a myiasis-producing species, but not so common as *xanthina*.

Accidental Myiasis-producing Flies.

In this group are included an assemblage of unrelated Diptera—the larvae of which occasionally find their way into the intestinal tract of man. They normally breed outside the human body in organic and vegetable matter, some of which is used as human food, and people who are not particular with regard to what they eat become infested. It should be clearly understood, however, that these flies do not intentionally deposit their eggs or larvae in certain human foods in order that their larvae may reach the intestinal tract; the food is merely their usual breeding ground. Although many of the OESTRIDAE live in their larval stages in the intestines of animals, they are not accidental myiasis-producing flies, the intestinal tract is the only place in which their larvae can reach maturity.

So far as I can gather, intestinal myiasis is an uncommon condition, even in countries like India, for in spite of the fact that I specially drew attention to it in the circular mentioned above, which was sent to every medical and veterinary officer, and in spite of the fact that some medical men have told me that it is very common in parts of the country, I received such larvae from only two cases.

The well known "rat-tailed" larvae of *Eristalis tenax* and *Helophilus pendulus*, which normally live in foul ditch water, may be acquired by those, particularly children, who drink such water, when they are likely to swallow large numbers of small larvae of these drone-flies. In the same way, vegetables, such as lettuces and mustard and cress, grown under insanitary conditions and eaten without being washed, may contain eggs and larvae of *Eristalis tenax* and allied species. The eggs and larvae of *Fannia* and *Anthomyia* may also be swallowed intact in uncooked vegetables, especially raw carrots. Onion fly larvae may be swallowed when eating diseased spring onions, and species of *Drosophila* in over-ripe fruit, such as bananas and oranges. *Sarcophaga* larvae are sometimes swallowed in imperfectly cooked meat, particularly cold meat, and game that is commencing to decompose. In the case of *Aphiochaeta xanthina (ferruginea)*, the larvae of this small Phorid are most probably swallowed in meats of all kinds, especially when beginning to decompose, as this substance is a favourite breeding ground for the fly. One remarkable case has been published in which the larvae, puparia and adults of this fly were passed in the faeces of a patient for a considerable time, suggesting that the larvae were able to reach maturity in the intestine, and the puparia remain alive, so that the adults could hatch out. Recently in Coonoor, I attempted to infect monkeys by feeding them on large numbers of eggs and larvae of this species, but although a most careful search was made for any stages in their excreta, I was never able to recover either larvae, puparia or adults. It would be worth while repeating this experiment, using only one monkey and making a more thorough search than I was able to undertake. Such small larvae as those of *Aphiochaeta* easily escape detection when the tray under such a monkey contains a considerable quantity of remains of food in addition to its faeces.

So far as I am aware, the larvae of the CALLIPHORINAE are unable to live in the intestine of man and animals, but in order to set aside any doubt on the subject I fed a dog with large numbers of eggs and larvae of some common Indian species, but not a single living larva was passed out, and it would appear that such larvae, when swallowed, soon die. But during the course of my enquiry into the myiasis-producing flies of India, two masses of eggs of *Chrysomyia megacephala* were sent me as having been passed out in the faeces of a patient. The eggs were intact, and

the medical officer was emphatic in his statement that they were actually passed out, and had not just been deposited on the faeces. In any case, *Chrysomyia megacephala* certainly does not breed in human excrement, so far as I know. It would be worth while carrying out some more experiments in this direction to see whether the eggs of CALLIPHORINAE can hatch out in the intestine, and the larvae reach maturity and be passed out in a living condition.

Lastly, it is necessary to refer to the larvae of *Fannia canicularis* from the urinary tract. There is at present no satisfactory explanation as to how such larvae can reach the human bladder. The usual explanation that they pass down the urethra when very small, seems to me to be highly improbable, at least in the case of the male urethra, for it will be remembered that the larva of *Fannia*, even when small, is not entirely smooth, and would cause very considerable irritation. The presence of such larvae in this organ is at present a mystery, and the subject requires to be re-investigated.

Identification of the Larvae of Myiasis-producing Diptera.

It will be remembered that the larvae of the higher Diptera are soft cylindrical maggots, usually of a greyish white to yellowish white colour. The head end is pointed and the body gradually increases in diameter backwards, the posterior end being truncated, with a concave surface looking upwards and backwards. Such a larva is divided into segments, the number of which is at present a matter of dispute, and it is not possible to homologise them with those of the adult. The head contains a characteristic skeleton consisting of a number of sclerites, spoken of as the cephalopharynx. The mouth is armed with a pair of mandibular hooks, and the anterior spiracles open at the sides of the apparent third segment. The posterior stigmata are placed on the concave surface of the apparent eighth abdominal segment. Banks, MacGregor and Metcalf have drawn attention to the value of the posterior stigmata in determining the larvae of the higher Diptera. Metcalf in particular says that, "So superior are the characteristics drawn from this part of the larva, that I regard most descriptions which omit consideration of them as practically worthless. For in most cases the general features of shape, colour, etc., may be found to apply almost equally well to other species. The most available, absolutely diagnostic characters are to be found on the posterior stigmata." In my own studies of the larvae of Diptera I have found that the characters of the posterior stigmata, cephalopharynx and anterior spiracles, taken together, afford the best and only reliable means of accurately determining the larva of any species of Diptera, and more particularly of those of the higher Diptera. In making a preparation of the posterior stigmata of a Muscid larva for purposes of identification, I always make it a rûle to include the cephalopharynx and anterior spiracles as well. I will now shortly describe these structures in the various types of larvae of the myiasis-producing Diptera, and point out how their characters can be utilised in determining any particular larva.

Posterior stigmata. In the third-stage larvae of all the higher Diptera the posterior stigmata consist of a pair of chitinous plates, which, when cleared in caustic potash, are seen to be surrounded by a ring of chitin, usually spoken of as the peritreme. Situated within this ring there are three or more openings which lead into the tracheae. Each opening is guarded by a number of delicate chitinous rods, giving the appearance of a grating; these rods form a network across the inner side of the openings. Plate 5, fig. 1, represents a vertical section through one of the stigmatic plates of the third-stage larva of *Pollenia stygia*. The deeply shaded portions represent the chitinous parts of the plate, and the lighter-shaded parts the epidermis. The three slits open into a large cavity, to the margins of which the trachea is attached; Lowne termed this cavity the vestibule. Just inside each slit there is a series of branched yellow chitinous rods, known as the grating, and lining the whole cavity a delicate network of epidermal fibres. The grating is evidently of use in preventing

the entry of foreign particles into the vestibule, and the epidermal fibrous network probably aids in retaining the air in the vestibule. The tracheae are lined externally by characteristic peritracheal cells. Situated on the inner and lower side of each plate, and usually within the chitinous ring, there is a small raised area, spoken of by Banks as the "button." In a vertical section through this structure it will be noted that it is a fine channel into the vestibule and is lined by a layer of peritracheal cells; so far as I can ascertain, it is an accessory opening, but I am unable to say at present whether it is functional or not. It is certainly not a point of attachment for muscles, as it is within the vestibule. This short description will enable the reader to understand this wonderful bit of apparatus. All the types which I have sectioned are of similar structure, no matter whether the tracheal slits be straight, as in the CALLIPHORINAE, curled as in *Musca*, or multiple as in *Oestrus* and allied genera, so that I can see little use in splitting them up into various types according to the shape of the slits. The important point to be ascertained is whether the straight or the curled slit is the more primitive, and this can only be ascertained by a comparative study of the stigmatic openings of a large number of the first stage larvae of the higher Diptera. An oval opening, such as is present on the anterior spiracles of most Dipterous larvae, seems to be the most primitive type, and from such an opening the various slits seen to-day in the posterior stigmata of the higher Diptera may have originated, but this is at present mere conjecture.

Turning now to the various kinds of slits, leading into the tracheal vestibule of the posterior stigmatic openings, we note the following types:—(1) Curled slits, (2) straight slits, and (3) round or oval openings.

1. *Curled slits.* This type of opening is characteristic of the larva of *Musca* and allied genera, the three openings occupying an excentric position on the plate, and the ends of the upper and lower appearing to coalesce with those of the middle slit. The button area is well within the chitinous ring, which, in this case, is often D-shaped and broad. In Plate v, figs. 2, 3, 4 and 5, are illustrated the posterior stigmata of *Musca domestica, Musca nebulo, Musca humilis* and *Philaematomyia crassirostris*, and without going into details it will be seen that, though very closely similar to each other, it is possible to note small distinctions sufficient for determining the species. But I would like to point out that the determination is considerably facilitated by comparing the structure of the cephalopharynx and anterior spiracles of each species at the same time. Recently I was able to determine the larva of *Musca* (*Philaematomyia*) *crassirostris* sent me from a case of intestinal myiasis by comparing the posterior stigmata with those of Indian species of *Musca*. Curled slits are also seen in the posterior stigmata of the larvae of the GASTEROPHILINAE, especially in the larvae of the species of *Gyrostigma*. Here, however, the grating is simpler than in the larvae of *Musca*.

2. *Straight slits.* This type of slit is characteristic of the opening of the posterior stigmata of the larvae of the CALLIPHORINAE, SARCOPHAGIDAE and some OESTRIDAE, such as the larvae of *Cobboldia*. In the larvae of the CALLIPHORINAE the posterior stigmata are of two kinds, one typically seen in the larvae of *Calliphora* and *Lucilia*, in which there is no break in the chitinous ring and the button is enclosed by it; the other in *Chrysomyia* and *Cochliomyia*, in which the ring of chitin is so thin on the inner and lower angle of the plate as to give the appearance of a break, the button lying in what is but a thin layer of chitin. This type is illustrated in Plate vi, figs. 9, 10 and 11, which represent the posterior stigmata of *Calliphora erythrocephala, Lucilia sericata* and *Lucilia argyricephala*, all drawn to the same scale. Further, it should be noted that in each of these there are characteristic breaks in the chitin, between and close to the slits, appearing as round or oval spaces; these clear spaces are extremely constant in the same larva. This close similarity between the posterior stigmata of *Calliphora* and *Lucilia* makes it difficult to separate the larvae of *Calliphora erythrocephala* from those of *Lucilia sericata*. Veterinary officers may find

this so, when they have to determine a larva taken from a sheep in this country. A careful examination of the plates when cleared in caustic potash and mounted on a slide will, however, help to separate the species. In the larva of *Calliphora erythrocephala*, as well as in that of *C. vomitoria*, the plates are distinctly larger and further apart than those of the larva of *Lucilia sericata*. In addition, in *Calliphora* there are two processes of the rim which project in between the upper and middle slit, and the middle and lower slit, whereas in *Lucilia sericata* there is only one projection between the middle and lower slit. These points, together with certain differences between the cephalopharyngeal skeletons and anterior spiracles of the two species, will make identification easy, but it is necessary to point out that mere examination of the larvae with a hand lens is not sufficient. Plate vi, fig. 13, illustrates the posterior stigmata of the third-stage larva of *Anastellorrhina augur*, and it will be noted that they are very similar to those of *Calliphora*. This alone, in my opinion, indicates the affinity of this blow-fly. The larva of *Cynomyia cadaverina* also has posterior stigmata of this type, as is seen in fig. 9 ; here, however, the clear spaces are not seen. The posterior stigmata of *Lucilia argyricephala* are smaller than those of *L. sericata* and more widely separated.

In the larvae of *Chrysomyia* and *Cochliomyia* the posterior stigmata appear to have a break in the chitinous ring on the lower and inner face, the plates are, as a whole, larger, and the button area is situated at the lower angle. Plate vi, figs. 14, 15, 16 and 17, illustrate the posterior stigmata of the larvae of *Chrysomyia megacephala, Chrysomyia bezziana, Cochliomyia macellaria* and *Phormia regina*, which also belongs to this group. It is interesting to note that in the case of the two myiasis-producing species, *macellaria* and *bezziana*, the slits are short and wide, those of *bezziana* having characteristic clear spaces between and near the slits ; these two flies are evidently very closely related.

Apart from other differences, such as the shape of the truncated posterior end, the larvae of the SARCOPHAGIDAE can always be distinguished from those of any of the CALLIPHORINAE by noting that the posterior stigmata are situated in a deep cleft, and that the internal slit slopes downwards and outwards, the middle almost straight down, and the outer slit a little inwards and backwards. The plates are always large and the slits long and somewhat narrow, and there is a characteristic break in the chitinous ring at the inner and lower angle ; the posterior stigmata of the third stage larvae of a species of *Sarcophaga* taken from a case of cutaneous myiasis in India are shown in Plate vi, fig. 18. The cephalopharynx and anterior spiracles of the larva of *Sarcophaga* are also very distinct, as I will point out further on, so that there should never be any difficulty in identifying a larva of this family of flesh-flies.

The posterior stigmata of the larvae of the elephant bots are very characteristic. The plates have here coalesced and the chitinous ring is feebly developed, the margins of the ring being probably represented by an island of chitin on the inner face. The slits are long and almost straight, situated close to one another; fig. 6, Plate v, illustrates the posterior spiracles of the third-stage larva of *Cobboldia elephantis* from the Indian elephant. The button area has apparently disappeared in this type of posterior stigmata. On larval structure alone, then, *Cobboldia* suggests affinities with a Calliphorine on the one hand and a *Sarcophaga* on the other.

3. *Single round or oval openings*. This type of posterior stigmata is well seen in the third-stage larva of the sheep nose-bot, *Oestrus ovis*. The plates are large, somewhat kidney-shaped, and the whole surface is dotted with minute openings of varying shapes and sizes. The button area is well marked and almost central in position. A similar plate is seen on the larva of the camel bot, *Cephalopsis titillator*, Plate v, fig. 7 ; the button area here is situated about the middle of the inner face of the plate, and is somewhat difficult to see. The posterior stigmata of the larva of *Hypoderma* (Plate v, fig. 8) also belong to this type, the openings here being arranged in more

or less regular rows, with strong bars of chitin projecting in between them. This type of posterior stigmata would, at first sight, appear to be extremely complicated, but I am inclined to think that they merely represent a breaking up of the original long slit into smaller ones to allow of a larger amount of air being taken in. The origin of this type can, however, only be determined by a comparative study of the first-stage larvae of a number of different species.

Cephalopharynx. This structure in the third-stage larva of the higher Diptera consists of a number of paired sclerites, some of which have fused, articulating with each other to form a strong chitinous skeleton. At the anterior end there is a pair of

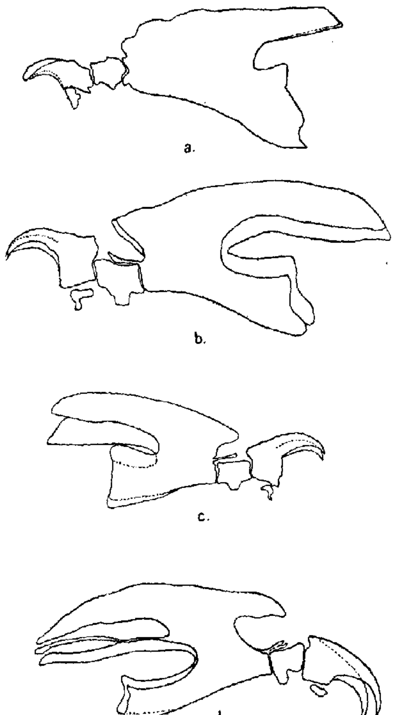


Fig. 1.—Cephalopharyngeal skeletons of third-stage larvae of: (*a*) *Musca nebulo*; (*b*) *Calliphora erythrocephala*; (*c*) *Lucilia sericata*; (*d*) *Sarcophaga* sp.

mandibular sclerites or hooks, each with a broad base, which project between the oral lobes and are used by the larva to attach itself to any object, and also in progression. Articulating with the ventral surface of the base of each hook there is a small, irregular sclerite, which Hewitt speaks of as the dental sclerite. Posteriorly the base of each mandible articulates with an irregularly shaped sclerite, which consists of two parts fused ventrally. These, again, articulate with small processes on the anterior end of the large pharyngeal sclerite, which at once suggests the fulcrum of the adult fly, and is shaped like the old-fashioned Spanish stirrup-iron.

The shape of the mandibular sclerites and the fulcrum (pharyngeal sclerite) is very characteristic in the third stage larvae of the different genera of the higher Diptera. In fig. 1 (*a–d*) the cephalopharyngeal skeletons of the third-stage larvae of *Musca nebulo, Calliphora erythrocephala, Lucilia sericata* and *Sarcophaga* are illustrated; all being drawn to the same scale. The differences are obvious, and therefore I do not intend here giving a detailed description of them. It is, however, necessary to point out that in the case of the larvae of *C. erythrocephala* and *Lucilia sericata* the differences are small, but nevertheless sufficient to determine the species. I will on another occasion deal at length with the structure of the cephalopharyngeal skeletons of a number of the larvae of the higher Diptera. I would, however, like to point out that in the larva of *Musca* and allied genera there are always two mandibular hooks, and not one, as is usually stated in the books and papers on the subject. This error is no doubt due to the fact that the left hook is shorter and narrower than the right, and is therefore easily overlooked. It is a valuable diagnostic character in this group.

Anterior spiracles. The anterior spiracular openings are always situated at the sides of the lower border of the apparent third segment. Each consists of a fan-shaped

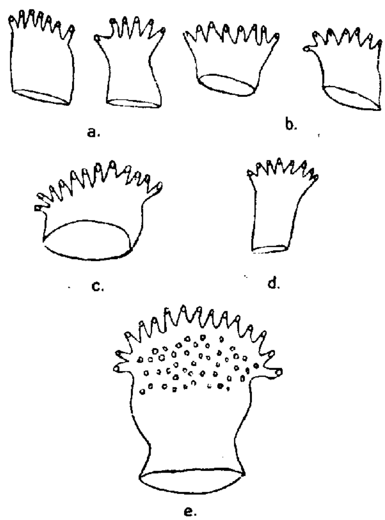


Fig. 2.—Anterior spiracles of third-stage larvae of: (*a*) *Musca domestica*; (*b*) *M. nebulo*; (*c*) *Calliphora erythrocephala*; (*d*) *Lucilia sericata*; (*e*) *Sarcophaga* sp.

chitinous structure with a varying number of small finger-like processes at the apices of which there are oval openings. These openings lead into a miniature vestibule, which is continuous with a large trachea; in the majority of the third-stage larvae the anterior spiracles are functional. They are always absent in the first-stage larva, and appear only in the second instar. Although there is great variation in the number of the finger-like projections in the same species, and even in the same larva, these structures are very useful for diagnostic purposes when taken along with the characters of the posterior stigmata and the cephalopharyngeal skeleton. In the third-stage larva of *Musca domestica* (fig. 2, *a*) there may be five, six, or seven processes; in *M. nebulo* (fig. 2, *b*) seven or eight; in *Calliphora erythrocephala* (fig. 2, *c*) eleven or

twelve; in *Lucilia sericata* (fig. 2, *d*) seven or eight. In *Sarcophaga* (fig. 2, *e*) the anterior spiracle is large, and there may be sixteen or more processes, and the vestibule has many small, clear circular areas.

I have, I think, now shown that if the characters of the posterior stigmata, cephalopharyngeal skeleton and anterior spiracles are taken together, the species to which any given larva belongs can be determined with certainty.

The following key to the larvae of some of the more important myiasis-producing Diptera (exclusive of the OESTRIDAE) will be useful for reference.

Key for Identification of some of the Larvae of the Myiasis-producing Diptera.

1. Larvae with fleshy processes; posterior spiracles at the end of tubercles or a tube.

(*a*) Small broad, dirty white larvae about 4 mm. in length, with small pointed fleshy processes in pairs on dorsum, increasing in length from before backwards; two long fleshy processes at sides of last segment, which is the broadest; posterior stigmata on brown chitinous tubercles, each with a narrow opening; movements caterpillar-like *Aphiochaeta xanthina* (*ferruginea*).

(*b*) Similar larvae, with hairy processes. .. .. *A. rufipes.*

(*c*) Medium-sized to large larvae with long pointed fleshy processes dorsally and laterally, increasing in length from before backwards, with small spines at their bases, shaft and ends bare; body compressed dorso-ventrally; posterior stigmata stalked, consisting of four lobes, each with an opening situated on dorsum of sides of apparent 8th segment .. .. *Fannia canicularis.*

(*d*) Fleshy processes with numerous branches, giving the process a feathery appearance .. .. *Fannia scalaris.*

(*e*) Medium-sized to large larvae with long pointed fleshy processes with a small tuft of spines at their apices; posterior stigmata in cleft at end of apparent 8th abdominal segment, consisting of large chitinous plates with broad rims, and three straight slits directed downwards and inwards *Chrysomyia albiceps* (*rufifacies*), *C. varipes.*

(*f*) Large soft larvae; integument covered with hairs and spines; seven pairs of short pseudopods on ventral surface; posterior stigmata situated at the end of a long tube, which can be telescoped or extended at will *Eristalis, Helophilus.*

1'. Medium-sized to large smooth larvae without any fleshy processes; posterior stigmata normal, not at the end of tubercles or a tube .. .. .. 2.

2. Posterior stigmata somewhat D-shaped; button area situated well within the ring; slits curled.

(*a*) All slits with three convex loops outwards .. *Musca domestica* and allies.

(*b*) Upper and lower slits with two loops, convex externally; middle slit with only one .. .. *Philaematomyia.*

2'. Posterior stigmata large, rounded or oval, with straight slits .. .. 3.

3. Chitinous ring complete and inclosing button area. *Calliphora, Lucilia, Cynomyia.* (For distinctions see drawings of posterior stigmata.)

3'. Chitinous ring incomplete .. .. 4.

4. Slits all directed downwards and inwards. *Chrysomyia, Cochliomyia, Phormia.* (For distinctions see drawings of posterior stigmata.)

4'. Internal slits comma-shaped, directed downwards and outwards; middle slits almost straight down; outer slits directed downwards and inwards *Sarcophaga.*

I will now suppose a medical or veterinary officer has a case of myiasis, and wishes to know how best to set about rearing the larvae, breeding out the flies and identifying at least the genus to which the larva belongs. If the case is one of dermal or subdermal myiasis, for instance a cut, sore or wound on the human body or that of an animal, there should be no difficulty in obtaining a number of living larvae. It is sometimes quite easy to extract the larvae without injuring them, but in the case of *Chrysomyia bezziana* the strongly developed, backwardly directed spines catch in the tissues, and, as often as not, the larva is torn in half, and then is only of use for purposes of identification. It is best to apply a small quantity of glycerine or very dilute chloroform water to the area where the larvae are, and then some will emerge, or so alter their positions that they can be extracted without damage. It is very probable that the larvae are all at the same stage, though there may be more than one species present. As many as can be removed alive should be placed in a tube, and one or more then dropped into boiling water in order to stretch them out and render examination more easy. The truncated end should be examined with a hand lens, and if the posterior stigmata are small and there are only two slits the larva is a second-stage one. A few should now be preserved in 80 per cent. alcohol, after killing them by dropping them into boiling water or hot 70 per cent. alcohol, and a label with details written in pencil put in the tube, which should be well corked. It is now necessary to rear the remaining living larvae, and this is best accomplished by placing them on a piece of meat, or in the mouth of a dead bird or small animal. Those who have not reared any of the larvae of the myiasis-producing Diptera may be misled by thinking that this part of the investigation is quite easy, but I would like to warn them that this is by no means the case; indeed it is by far the most difficult part of such an inquiry. In the Tropics great care has to be taken to prevent other blowflies, and particularly species of *Sarcophaga*, from laying their eggs or depositing their larvae, as the case may be, in the meat or the body as soon as it begins to decompose. I have tried every kind of receptacle in which the meat, etc., was placed, and have even sealed the lid with vaseline, but in every case the larvae of other blowflies, and especially *Sarcophaga*, have made their way in, and then the special larvae removed from the case of myiasis have soon disappeared. Fabre long ago suggested that a paper bag was the best way to prevent blowflies from laying their eggs in meat; and taking advantage of this suggestion I placed the meat containing the larvae to be reared in several sheets of newspaper, turning down the ends and tying it up into a packet. No larvae can now find their way into the packet, provided that the moisture which exudes from the decomposing meat or body does not soak right through, and forming a wet patch under the packet, so soften the paper as to allow small larvae to eat their way in and reach the meat. As soon as the outer part becomes wet, the packet should be wrapped up in several fresh sheets of newspaper; and this may have to be repeated several times. Although large numbers of eggs may be laid under the packet, as long as the outer layers are dry the larvae cannot make their way to the meat. When the special larvae are nearing maturity, they crawl out into the folds of the paper and pupate, so that it is necessary to examine the packet for such larvae every two or three days; larvae about to pupate can always be recognised by their yellowish-white colour and the absence of food in their alimentary tracts. Several mature larvae should be preserved, as noted above, the remainder allowed to pupate, and the puparia later removed and placed in tubes with well-fitting corks. From 24 to 36 hours after the flies have hatched they should be killed and pinned with their empty puparia; and all dead larvae, whether first, second or third stage, preserved in one tube containing 80 per cent. alcohol.

I have collected most of the Indian CALLIPHORINAE and their early stages by placing dead animals out in the open, and when a female of any species came to lay its eggs, it was carefully observed, and after a large number of eggs had been laid, in most instances the fly was caught, pinned and identified. The mass of eggs was then removed by cutting off a piece of tissue, so as not to injure the eggs; a few were then

placed separately in a dry tube in order to preserve the first-stage larvae as soon as they hatched, and the remainder of the eggs were placed in the mouth of a dead bird or animal, which was then wrapped up as explained above. Some second-stage larvae were collected about the second or third day, the third-stage larvae later, and finally the flies were bred out of puparia. In this way I was able to obtain the eggs, first, second and third-stage larvae, of a large number of the commoner Indian species; such material is extremely valuable for comparative studies.

This method of rearing the larvae of the semi-specific myiasis-producing larvae is very satisfactory. In the case of the specific myiasis-producing species, such as *Chrysomyia bezziana* or *Wohlfahrtia magnifica*, it is a mere waste of time attempting to rear their larvae in decomposing animal matter. They can only be reared to maturity in living tissues. It is therefore obviously necessary to be able to recognise the second-stage larvae of such a species as *Chrysomyia bezziana*—the first stage is very seldom found, as it is a very short one. The second-stage larva of *Ch. bezziana* is fortunately very characteristic, and I am not acquainted with any other species which has a similar larva. The segmental spines are extremely well developed and stand out as dark bands; the anterior spiracles consist of five finger-like processes; there is a well developed short accessory belt of spines at the sides of the abdominal segments 1 to 7 in front of the segmental bands, and the spines on the ventral pads consist of two separate rows. All the spines become weaker after the 5th segment, and are poorly developed on the 8th. The posterior stigmata are situated on a well developed plate, and consist of two rather broad straight slits directed backwards and inwards; the tracheae give off many branches after the vestibule, so that the 8th segment has a dark colour, owing to these showing through the integument.

If the case is one of rhinal, oral, aural or vaginal myiasis, the larvae should be removed by spraying the parts with glycerine, or even with a little weak chloroform water; it may be difficult to dislodge the larvae when they are high up in the accessory nasal sinuses, but it is nearly always possible to get a few. Medical officers in India have always been able to send me a considerable number of larvae from such cases. The mature larvae of *Ch. bezziana* when removed from the tissues should be placed in some earth in a cigarette tin and allowed to pupate.

With the help of the above key, medical and veterinary officers should find no difficulty in determining the genera to which the larvae belong, by simply examining the posterior stigmata with the aid of a pocket lens magnifying 15 times. The presence of fleshy processes on the larva points to its being either *Fannia*, *Aphiochaeta* or such CALLIPHORINAE as *Chrysomyia albiceps* or *varipes*, two Oriental and Australian blowflies. If the larva is smooth, note whether the stigmatic slits are curled or straight. If curled it belongs to the MUSCINAE, if straight, to either *Calliphora*, *Chrysomyia*, *Lucilia* or *Sarcophaga*. With the aid of the key, and the drawings accompanying these notes, the larva can be accurately placed in any of these genera. If there is any doubt as to whether the chitinous ring is complete or not, shave off the end of the 8th abdominal segment with the stigmata with a razor, and clear it in 10 per cent. caustic potash, and mount, after dehydration, in Canada balsam on a slide. The determination of the species should, in most cases, be left to a specialist.

All *Sarcophaga* larvae should be reared to maturity, and the adults hatched out and carefully pinned, especially the males, as there is no means at present of determining the larvae of these flies. Any such material would be most valuable.

In the case of the OESTRIDAE, all of which are specific myiasis-producing flies, success in hatching out the adults is only possible if the mature larvae, which have of their own accord left their host, can be obtained. Such larvae should be placed in some earth in a cigarette tin and should be handled as little as possible. The mature larvae of the OESTRINAE are usually much darker than the immature specimens; in others the skin becomes dark yellow and harder. Mature larvae can sometimes be obtained in places where their hosts are in the habit of lying up during the evening,

for it is usually then that they leave them. The camel bot larvae always leave their hosts in the evening, when the camels are feeding. They will be found buried in the earth and under leaves, etc.

In the case of recently killed wild animals, such as deer, antelopes, pig, wart-hogs, rhinoceroses, zebras, elephants, etc., if the observer has time, many larvae may be collected from the nose, accessory sinuses, throat, nasopharynx, skin, stomach and duodenum. The largest and the smallest larvae should be specially selected, for in this way the nearly mature third-stage larvae, and sometimes the second stage, will be obtained. The larvae should be placed in tubes until they can be preserved by killing them in boiling water or alcohol. I hope those who have opportunities while on *shikar* trips in Africa and India will collect any Oestrid larvae they may find and preserve them as described above and send them to Dr. Marshall. The hosts of many of these flies are gradually being exterminated, and with them these interesting insects will disappear before we have time to learn all there is to be learnt from their larvae.

The first-stage larvae of all oviparous OESTRIDAE can be obtained by collecting the eggs from the hairs, skins, tusks, trunk, etc., of their respective hosts, whether dead or alive. The hairs, or the piece of skin, should be cut off and placed in a dry tube with a well-fitting cork, and watched every day. In a few species the larvae hatch out of their own accord, such as those of *Gasterophilus veterinus* (*nasalis*), *Hypoderma bovis* and *H. lineata*; others again only require moisture, when they at once escape from the eggs, as in the case of the larvae of *Cobboldia elephantis*; and others again require friction as well as moisture, such as the larvae of *Gasterophilus intestinalis.* Recently Captain Cross, C.V.D., sent me a large number of horses' hairs with eggs of *Gasterophilus intestinalis* var. *bengalensis* from the legs of horses in the Punjab. The larvae could not hatch out when the eggs were only moistened; but as soon as they were compressed, the opercula broke away. This friction is applied by the tongue of the horse.

All such first-stage larvae should be dropped into hot 70 per cent. alcohol and placed in a small tube with a good cork, which must be paraffined in order to prevent the alcohol escaping.

In the case of the larviparous OESTRIDAE, such as the OESTRINAE, the first-stage larvae can only be obtained by catching a female, either when depositing its larvae at the entrance to the nose, or in the neighbourhood of its host, on the off chance that it may contain larvae ready to be extruded. The flies should be preserved in 70 per cent. alcohol, for the larvae can always be dissected out afterwards; and the fly can be identified from such spirit specimens. This also applies to species of *Wohlfahrtia* and *Sarcophaga,* for these flies are larviparous in habit.

In concluding these notes, I would like to take this opportunity of thanking all those who have given me material bearing on this subject. Owing to the long distance it will of course be impossible to send me living larvae, so that the breeding out of the flies will, in the first instance have to be carried out on the spot. But as more material other than Indian becomes available, it will be possible to give a complete description with a key to the larvae of the myiasis-producing Diptera, so that a Medical or Veterinary Officer when he comes across a case may be in a position to determine the species without having to breed out the fly; breeding experiments are always difficult, take up a lot of time, and, as often as not, fail. Medical and Veterinary Officers have unique opportunities of collecting the larvae of these flies and of studying their habits, but I believe many are deterred from doing so because there is no easily accessible account of these interesting parasites of man and animals; I trust these notes will in some way fill this hiatus. And lastly, I would like to point out that comparative studies of the first, second, and third-stage larvae of these higher Diptera cannot but lead to a better knowledge of the relationships of the adults.

A REVISION OF THE MOSQUITOS OF THE PALAEARCTIC REGION.

By F. W. EDWARDS.

(Published by permission of the Trustees of the British Museum.)

For some years after the intensive study of mosquitos began in tropical countries, surprisingly little interest was taken in the European species, particularly those of Northern Europe. Ficalbi had published his monographic revision in 1896–99, but from then until 1914 very little further had been done; the adults were assumed to be more or less known, though very few of the larvae had been described. Since 1914, however, a great deal of work has been done all over Europe, bionomic as well as systematic, and considerable advances have been made in every branch of our knowledge of these insects.

The present paper was commenced early in 1919, with the study of a number of large collections received at the British Museum from Italy (Mr. E. Hargreaves), Macedonia (Capt. J. Waterston), Palestine and Mesopotamia (Capt. P. J. Barraud), and Egypt (Major E. E. Austen). Shortly afterwards a correspondence with Dr. Wesenberg-Lund, of Copenhagen, made it evident that there were many more species in Northern Europe than had previously been supposed. I therefore determined to attempt a revision of the Palaearctic mosquito fauna, and with this end in view wrote to the Dipterists in charge at various continental museums, as well as some private collectors, for the loan of material for determination or re-determination. Collections were sent in response to my requests by Dr. R. Frey, Helsingfors Museum; Dr. E. Bergroth, Jämsa, Finland; Dr. Y. Sjöstedt, Stockholm Museum; Dr. Wesenberg-Lund, Hillerod, Denmark; Dr. G. Enderlein, Berlin Zoological Museum; Dr. W. Horn, Berlin-Dahlem Entomological Museum; Herren L. Oldenberg and B. Lichtwardt, Berlin; M. E. Séguy, Paris Museum; Dr. H. Zerny, Vienna Museum; Dr. K. Kertész, Budapest Museum; Prof. M. Bezzi, Turin; and odd specimens were also received from Dr. Lundbeck, Copenhagen Museum; and Dr. E. Martini, Hamburg. A further valuable collection was sent by Mr. S. Yamada from Japan in 1916, and additional Japanese and Chinese collections were made by Dr. W. A. Lamborn in 1921. To all who have helped me in this way I wish to express due thanks, as also to other correspondents and colleagues for help in other ways.

The publication by Dr. E. Martini of his admirable paper, "Über Stechmücken," in August 1920, and by Dr. Wesenberg-Lund of his equally excellent treatise on Danish mosquitos early in 1921, have to a great extent covered the ground which it was intended to investigate in this paper, and have also gone much further in giving an account of the life-history of the majority of the European species. The present paper, while not claiming to make any very considerable further contribution to our knowledge of these species, will serve to correlate and summarise the results of these and other workers, and by including the whole Mediterranean region give a rather more comprehensive view of the subject.

The geographical limits adopted here are those most usually given to the Palaearctic region, *i.e.*, Europe, North Africa, as far south as the tropic; the Atlantic Islands; Asia Minor; North Arabia, including the head of the Persian Gulf; North

Asia as far as the Himalayas; North China; Japan. Mosquitos have been more or less carefully collected over practically the whole of this area, the least known portions being perhaps North Russia and North and Central Siberia. Spain also has not yet been thoroughly worked. Iceland should be included in the area, but no mosquitos have yet been recorded or received from that country.

The study of the various collections enumerated above indicates that the mosquito fauna is fairly homogeneous over the greater part of the area, but there are two parts which, so far as this group of animals is concerned, would seem to be better classed in the Oriental region. These are the area immediately round the head of the Persian Gulf, and the southern islands of Japan, at least as far north at Tokio. In the former area there is a very large, perhaps a predominating admixture of Oriental forms, while round Tokio the fauna appears to be of an almost purely Oriental type. If these two areas had been excluded from consideration, the number of species dealt with would have been much less; but it was thought that the usefulness of this paper might be increased by keeping to the wider limits.

The total number of species dealt with is as follows :—

Anopheles, 19.	*Orthopodomyia*, 1.
Uranotaenia, 2.	*Taeniorhynchus*, 1.
Rachionotomyia, 1.	*Aēdes*, 38.
Megarhinus, 3.	*Armigeres*, 1.
Theobaldia, 7.	*Lutzia*, 1.
	Culex, 20.

The faunistic relationship of these species may be analysed as follows :—

Intrusions from the Oriental Region.			Intrusions from the Ethiopian Region.	
In the West.	In the East.		In Algeria, etc.	In Egypt and Palestine.
A. stephensi.	*An. lindesayi.*	*Arm. obturbans.*	*An. costalis.*	*A. mauritianus.*
C. tritaeniorhynchus.	*U. bimaculata.*	*L. vorax.*	*Ae. vittatus.*	*A. pharoensis.*
C. vishnui.	*R. bambusa.*	*C. hayashi.*		*C. quasigelidus.*
C. fatigans.	*M. towadensis.*	*C. bitaeniorhynchus.*		*C. laurenti.*
	A. togoi.	*C. sinensis.*	In Mesopotamia.	*C. tritaeniorhynchus.*
	A. japonicus.	*C. tritaeniorhynchus.*		
	A. koreicus.	*C. vishnui.*		
	A. niveus.	*C. fatigans.*	*A. rhodesiensis.*	
	A. albopictus.			

The remaining 70 species may be said to comprise the true Palaearctic fauna (though a number of them spread into adjoining regions). As might be expected, there are considerable differences between the North European and the Mediterranean faunas. The former shows very strong affinities with the Nearctic fauna, and a considerable number of the species seem to be common to both Europe and North America, while others have obviously representative forms in the two regions. The species which I consider either identical or only varietally distinct are: *Anopheles maculipennis, Theobaldia alaskaensis, Aēdes dorsalis, A. lutescens, A. excrucians, A. alpinus, A. cataphylla, A. diantaeus, A. sticticus, A. punctor, A. communis, A. intrudens, A. pullatus, A. vexans, A. cinereus, Culex apicalis, C. pipiens.* Nearly all these species are already known to occur throughout Europe and Siberia, and the two faunas may therefore be assumed to have mixed at a recent date by way of Eastern Siberia and Alaska. In one or two cases (*e.g., Anopheles maculipennis*) there seems to be definite evidence that the European fauna is more closely allied to that of Western than that of Eastern North America.

The following may be considered representative species :—

Europe.	North America.
Anopheles plumbeus.	*A. barberi.*
Theobaldia annulata.	*T. maccrackenae.*
T. glaphyroptera.	*T. impatiens.*
T. morsitans.	*T. dyari.*
Orthopodomyia pulchripalpis.	*O. signifer.*
Taeniorhynchus richiardii.	*T. perturbans.*
Aëdes semicantans.	*A. stimulans.*
A. rusticus.	*A. trichurus.*
A. geniculatus.	*A. triseriatus.*

It is of special interest to note that none of the European species in this list are at present known from Asia.

As might be anticipated, few, if any, of the purely southern species have any clearly recognisable North American representatives, but some of them have wide extensions of their range into the Ethiopian and Oriental regions. The most noteworthy of such species are *Theobaldia longiareolata* and *Culex tipuliformis*.

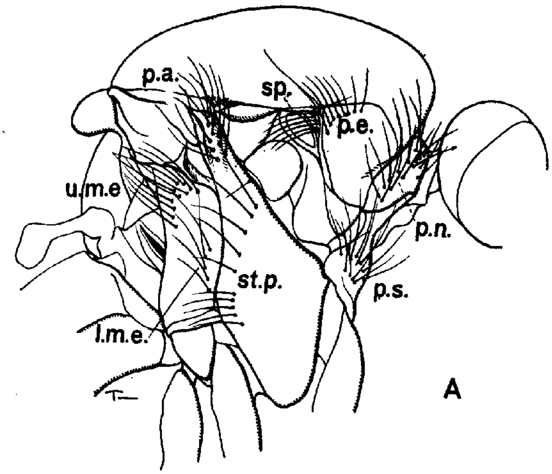
In the more northerly parts of the region the dominant group is the subgenus *Ochlerotatus* of *Aëdes*; the species of *Anopheles* which occur are all of the typical subgenus. Further south *Ochlerotatus* rapidly disappears, and begins to be replaced in part by species of *Culex*, and in part by other subgenera of *Aëdes*, while the Anophelines of the *Myzomyia* group become numerous.

I have endeavoured in this paper to revise the generic classification of the CULICIDAE on a sounder basis than has been used hitherto, by defining the genera primarily on characters which have no relation to sex. In previous papers I have tried to minimise the use of secondary sexual characters, as well as of the merely superficial characters of the scales, but found myself in some cases compelled to fall back upon these, or else on the male hypopygium. A closer study of the insects now enables me to point out what appear to be constant and important distinctions between most of the genera which are applicable equally to both sexes without being so artificial as the scale characters have been proved to be. Fortunately no changes are involved in our conception of the limits of the genera; these had been already soundly established by the study of the larvae, and the new characters adduced only confirm most of the conclusions already arrived at by a study of the early stages.

Several of the new distinctions employed are to be found in the thoracic chaetotaxy, and to explain these clearly I give explanatory figures of the pleural bristles in *Theobaldia annulata* and *Aëdes geniculatus*. The most important bristles for taxonomic purposes I find to be those occurring on the area in front of the prothoracic spiracle. This area is almost entirely occupied by the proepimeron, but there is a small, more or less triangular area immediately adjoining the spiracle which is separated from the proepimeron by a well-marked ridge. The bristles which are found on this small area I speak of here as the *spiracular* bristles. When present they project backwards, covering and protecting the spiracle. When the spiracular bristles are absent, their function is often assumed by the *proepimeral* bristles, which are usually situated in a row near the posterior margin of the proepimeron; it will sometimes be necessary to look closely in order to ascertain whether the bristles present are spiracular or proepimeral, or perhaps both; their position relatively to the above-mentioned ridge is the deciding factor. The two groups are obviously not homologous.

The other groups of bristles on the pleurae are apparently of less importance, and are for the most part more hair-like. They are as follows :—*Pronotal*, on the prothoracic lobes. *Prosternal*, on the prosternal lobes; a group which Christophers considers important in the ANOPHELINI, but which seems to be fairly constant throughout the CULICINI. *Post-spiracular*, a distinct group of some importance situated a little behind the prothoracic spiracle and below the margin of the mesonotum.

Pre-alar, a clump situated on the pre-alar prominence; always present, but variable in number. *Sternopleural*, the row which is nearly always present, extending vertically across the mesepisternum and mesosternum, almost in a line with the row on the



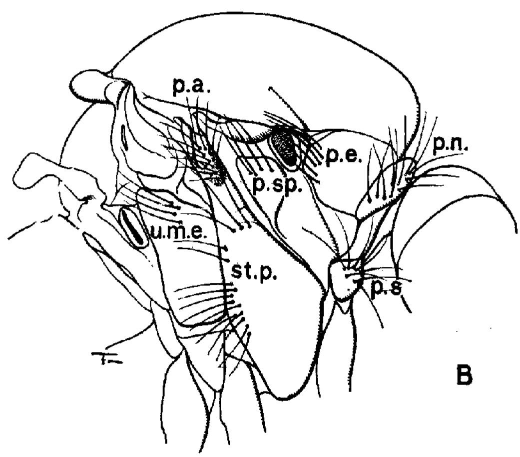


Fig. 1. Side view of thorax of (A) *Theobaldia annulata* and (B) *Aëdes geniculatus*, to show arrangement of pleural bristles. (Scales omitted.) Bristles: *p.n.*, pronotal; *p.s.*, prosternal; *p.e.*, proepimeral; *sp.*, spiracular; *p. sp.*, post-spiracular; *p.a.*, pre-alar; *u. m.e.*, upper mesepimeral; *l.m.e.*, lower mesepimeral, *st. p.*, sternopleural.

middle coxae. *Mesepimeral*, two groups whose position is indicated by the name; the *upper mesepimeral* bristles form a distinct clump or tuft which is always present; the *lower mesepimeral* are variable in number and have been used to distinguish the genera *Culex* and *Lutzia*.

I have studied also the mesonotal bristles, but although these vary greatly in number and development, I have not succeeded in discovering any differences which are of more than specific value. The same applies to the bristles of the legs, but those of the head sometimes offer useful generic characters. There are two great advantages which bristle characters have over scale characters. Firstly, they are obviously of much greater phylogenetic importance. Secondly, even when they are rubbed off they always leave a recognisable scar. A denuded specimen may even be more easy to examine than a perfect one, as the scales are sometimes liable to obscure the bases of the bristles.

In this paper I believe I have mentioned every name proposed for a mosquito taken within the region dealt with, but I have not as a rule given additional synonyms, nor have I attempted to unravel all the confusion caused by mis-identification, but have tried merely to give clear definitions of the specific concepts. A large number of the old descriptions are unrecognisable, and the types of many (some of Meigen's and all of Robineau-Desvoidy's) have apparently ceased to exist. Since, however, it is highly probable that the old names all apply to species which are known at the present day, I have endeavoured to form an opinion as to which species was most likely intended by the describer, rather than give a separate list of indeterminable species. I have not included Robineau-Desvoidy's *Culex flavovirens* and *C. viridis* in the synonymy, because I consider it obvious that they were CHIRONOMIDAE. Linnaeus' *Culex vulgaris* may very likely have been a species of *Aëdes*, but has been considered by Dyar and Knab to be a *Simulium*; it is therefore omitted. *Anopheles sacharovii*, *A. pseudopictus* var. *flerowi*, Portch., and *A. superpictus* var. *vassilievi*, Portch., referred to by Russian writers (see Review of Applied Entomology, B, ii, p. 108, and iii, p. 196), do not appear to have been described; at any rate I have been unable to trace the descriptions. For references to the original publications of *Culex annulatus*, de Fourcroy, *C. niveus*, Eichwald, and *C. pallipes*, Waltl, I am indebted to Mr. C. Davies Sherborn, who has kindly allowed me access to his manuscript.

Tribe ANOPHELINI.

Genus **Anopheles**, Mg.

As the careful and detailed researches of Christophers have shown, there are two main sections of the genus *Anopheles*, differing in small but quite easily definable characters, both in the adult and in the larva, and undoubtedly to be regarded as representing a very early separation of the genus into two distinct stocks. This separation, according to Christophers, probably took place at least as early as the Cretaceous. It is both desirable and convenient to recognise this important conclusion in our nomenclature, and I therefore accept the divisions proposed by Christophers (Ind. Journ. Med. Res. iii, p. 383, 1915) as subgenera. I do not consider that the differences are sufficiently important or sharply defined to warrant the full generic separation of the two old-world groups, nor do I consider it possible to subdivide either of these groups in a satisfactory manner, since the connections between their component species are so intricate and the intergradations so complete. As Christophers has pointed out, the subgenus *Anopheles* shows much more real diversity among its members than the subgenus *Myzomyia*, but when the species of the whole world are taken into consideration it is impossible to recognise clearly-defined divisions.

The eggs of different species of *Anopheles* show remarkable variations in the structure of the air-floats, while these appear to be constant for each species; in some instances, indeed, this is so markedly the case that the egg-structure (when known) affords the readiest means of distinguishing closely allied forms. I have therefore considered it worth while to collect into one block all the published figures of the eggs of Palaearctic *Anopheles*. These, with the two or three new ones which

are added, comprise all the species dealt with in this paper, except *A. mauritianus* and *A. sergenti*. It will be noted that the species in which the air-floats have undergone great reduction are *A. plumbeus*, *A. elutus*, *A. multicolor* and *A. turkhudi*. Dr. G. A. K. Marshall suggests that this reduction may be connected with the habit

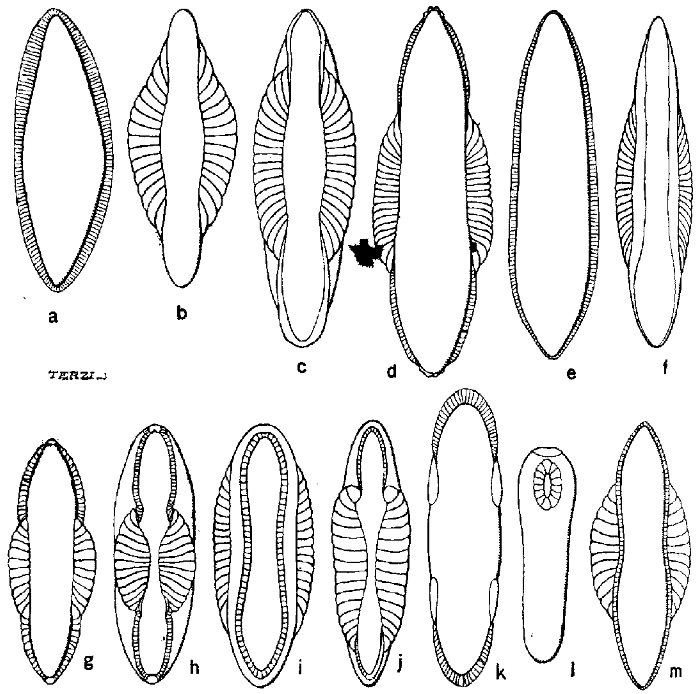


Fig. 1.— Eggs of Palaearctic species of *Anopheles*. *a*, *A. plumbeus*, Steph. (original); *b*, *A. algeriensis*, Theo. (after Sergent); *c*, *A. bifurcatus*, L. (after Martini); *d*. *A. maculipennis*, Mg. (original); *e*, *A. elutus*, sp. n. (original); *f*, *A. hyrcanus* (Pall.) (original); *g*, *A. pulcherrimus* Theo. (after Stephens and Christophers); *h*, *A. stephensi*, Theo. (after Stephens and Christophers); *i*, *A. costalis*, Theo. (after Patton); *j*, *A. rhodesiensis*, Theo. (after Patton); *k*, *A. multicolor*, Camb. (after Foley); *l*, *A. turkhudi*, Liston (after Stephens and Christophers); *m*, *A. hispaniola*, Theo. (after Sergent).

of breeding in water of high specific gravity (tanninised water in the case of *A. plumbeus*, saline water in the case of *A. multicolor*), in which large floats would perhaps not be necessary in order to keep the eggs on the surface during incubation. It is uncertain whether this explanation will apply to *A. elutus* and *A. turkhudi*.

Subgenus **Anopheles**, Christophers.

Ind. Journ. Med. Res. iii, p. 383 (1915).

Adult.—Cross-veins and bases of forks of wing-veins with dark scales. Costa largely dark (in Palaearctic species), with at most two pale spots, apart from a pale area in the apical fringe. Male hypopygium with two (rarely one or three) strong spines at the bases of the side-pieces, one or both of which are borne on a strong tubercle. Prosternal hairs usually numerous.

Larva.—Shaft of antenna with a branched hair (except in *A. plumbeus*). Palmate hairs lanceolate, without long terminal filament. Internal clypeal hairs generally close together.

The members of this subgenus exhibit considerable diversity, and some obviously fall together into groups, but when the species of the whole world are considered it does not seem profitable or even possible to recognise distinct subgenera. The nine Palaearctic species at present known may be distinguished by the following tables:—

Adults.

1. Wing-scales all dark; front femora cylindrical; female palpi slender, the scales appressed (*Anopheles*) 2
   Wings with many pale scales; front femora thickened at the base; female palpi and proboscis (except in *A. lindesayi*) shaggily scaled towards the base (*Myzorhynchus*) 6
2. Wing-scales uniform; base of upper fork-cell considerably nearer wing-base than that of the lower 3
   Wings normally with spots of darker, more densely aggregated scales; fork-cells somewhat shorter, their bases practically level 5
3. White frontal tuft absent; mesonotum unicolorous, with dark hair *algeriensis*, Theo.
   White frontal tuft present; mesonotum darkened at sides, with some pale hair and scales 4
4. Smaller, blacker species; a distinct patch of white scales on front of mesonotum .. .. *plumbeus*, Hal.
   Larger, browner species; scales on front margin of mesonotum narrower and not pure white .. .. *bifurcatus*, L.
5. Mesonotum unicolorous; wing-fringe all dark .. .. *elutus*, sp. n.
   Mesonotum darker at sides; fringe usually pale at tip of wing *maculipennis*, Mg.
6. Costa with only one pale spot (at the tip); hind femora with a conspicuous white pre-apical ring; front femora only slightly enlarged at the base *lindesayi*, Giles
   Costa with two distinct pale spots (normally); hind femora without pre-apical white ring; enlargement at base of front femora conspicuous .. 7
7. A white dot at base of costa, and a second near it .. .. *punctibasis*, sp. n.
   These dots absent 8
8. Fourth and fifth hind tarsal joints all white .. .. .. *mauritianus*, Grp.
   Fifth hind tarsal joint dark 9
9. Fourth hind tarsal joint dark except at the tip 10
   Fourth hind tarsal joint all white or whitish, *hyrcanus* var. *pseudopictus*, Grassi
10. Wing-markings usually more sharply defined; basal half of costa with dark scales only .. .. *hyrcanus*, Pall.
    Wing-markings more blurred; basal half of costa with some pale scales on its inner edge .. .. *hyrcanus* var. *mesopotamiae*, Chr.

Male Hypopygium.

1. Base of side-piece with only one strong spine .. .. *algeriensis*, Theo.
   Base of side-piece with more than one strong spine 2
2. Base of side-piece with three spines, two of them branched *bifurcatus*, L.
   Base of side-piece with two spines, both simple 3
3. Spines of claspette approximated, but not fused 4
   Spines of claspette fused into a spatulate process 5

4. Aedoeagus short and broad, without leaflets .. .. .. *plumbeus*, Hal.
   Aedoeagus long and narrow, with leaflets at the tip
   maculipennis, Mg.; *elutus*, sp. n.
5. Spatulate process long and narrow; ninth tergite without definite processes; long hair at middle of side-piece moderately developed
   lindesayi, Giles
   Spatulate process shorter and broader; ninth tergite with distinct processes; long hair at middle of side-piece stouter, almost spine-like .. 6
6. Processes of ninth tergite short and broad .. .. *punctibasis*, sp. n.
   Processes of ninth tergite elongate .. *hyrcanus*, Pall.; *mauritianus*, Grp.

Larvae.

1. A row of six large plumose hairs across middle of head 2
   These hairs vestigial, simple .. .. *plumbeus*, Hal.
2. Outer anterior clypeal hair thickly branched, dendriform 3
   Outer anterior clypeal hair simple or slightly branched .. *bifurcatus*, L.
3. Innermost shoulder-hair branched from base or nearly .. *mauritianus*, Grp.
   Innermost shoulder-hair branched only at tip, if at all 4
4. Palmate hairs on abdominal segments i–vii (always ?) .. *hyrcanus*, Pall.
   Palmate hairs on abdominal segments iii–vii only
   elutus, sp. n.; *maculipennis*, Mg.

The larvae of *A. algeriensis* and *A. lindesayi* are insufficiently described for inclusion in the above table; that of *A. punctibasis* is not yet described.

1. **Anopheles (Anopheles) algeriensis,** Theo. (fig. 2, b).

Anopheles algeriensis, Theobald, Mon. Cul. iii, p. 21 (1903).
Anopheles lukisi, Christophers, Ind. J. Med. Res. iv, p. 120 (1916).

Easily distinguished by the unspotted wings and the absence of a distinct tuft of long white scales on the front of the head. The mesonotum is uniformly dull light brown, and clothed with dark hair only, the small yellowish hairs or hair-like scales which are found in *A. bifurcatus* being absent in this species. In the female the second segment of the palpi is considerably longer than the first or the third and fourth together.

The male hypopygium, which has not as yet been described, is very distinct. The processes of the ninth tergite (ventral processes of Christophers) are very short, less than half as long as the breadth of the tergite. The side-pieces have a strongly differentiated bristle on the inner side near the tip, as in *A. bifurcatus*; there is a single very strong basal spine, situated on a large tubercle, with its tip bent; the outer basal spine is absent or represented only by one or two scarcely differentiated and inconstant bristles. The claspettes are trilobed, the first lobe bearing two or three strong, pointed, closely approximated spines, the second several short hairs, the third (innermost) three nearly equal, moderately strong bristles. The aedoeagus bears two or three pairs of long delicate leaflets at its tip.

The larva is unknown. Sergent, indeed, gives a short, incomplete description and some figures of a larva which he supposes to be *A. algeriensis*, but he was unaware of the real distinctions between *A. algeriensis* and *A. bifurcatus*, and his statements are insufficient to enable us to decide which of these species he had before him, or whether he had both. Sergent's figure of the egg is reproduced in fig. 2, *b*; it is not improbable, however, that this really represents the egg of *A. bifurcatus*.

The type of *A. lukisi* shows faint traces of pale banding on the hind tarsi; in the Mediterranean specimens the tarsi are entirely dark, but there appear to be no other differences. The colour of the mesonotum varies from yellowish to rather dark brown.

The species has a rather close resemblance to the Oriental *A. aitkeni*, and, as suggested by Barraud, it is probable that the specimens of *A. aitkeni* recorded from Palestine were really *A. algeriensis*. *A. aitkeni* is certainly a distinct species, since the upright scales of the head are very much narrower than in *A. algeriensis*, and the side-pieces of the hypopygium have two distinct basal spines.

Distribution.—Algeria (*Sergent*); Italy (*Hargreaves*); Macedonia (*Waterston*); Palestine (*Austen, Barraud*); Egypt (*Austen*); Mesopotamia (*Christophers*).

2. **Anopheles (Anopheles) bifurcatus,** L. (fig. 2, c).

Culex bifurcatus, Linnaeus, Syst. Nat. Ed. x, p. 603 (1758).
Culex claviger, Meigen, Klass. u. Beschr. i, p. 4 (1804).
Culex trifurcatus, Fabricius, Ent. Syst. iv, p. 401 (1794).
Anopheles villosus, Robineau-Desvoidy, Mém. Soc. d'Hist. Nat. Paris, iii, p. 411 (1827).
Anopheles grisescens, Stephens, Zool. Journ. xii (1828).
Anopheles antennatus, Becker, Mitt. Zool. Mus. Berlin, ii, p. 68 (1903).

This species varies a good deal in size and colour; small dark specimens might be mistaken for *A. plumbeus* and small light ones for *A. algeriensis*. Apart from the male hypopygial characters, which are absolutely diagnostic, *A. bifurcatus* may readily be separated from *A. plumbeus* and *A. algeriensis* by the other characters mentioned in the key.

The larva, which has been fully described by Lang, occurs generally in clean water with some weed, in rather shady situations; in the Mediterranean region it is frequently found in wells. The winter is passed in the larval stage, the adults dying off in the late autumn and the first brood appearing again in early spring.

A. bifurcatus is less domestic than *A. maculipennis* and does not so readily enter houses, but bites freely in the open.

Distribution:—Throughout Europe, North Africa (except desert regions) and Asia Minor. Turkestan (*Vassiliev*). Not found as yet further east. Apparently rarer in the far north.

South European specimens are commonly smaller than those from Central and North Europe, but are not otherwise distinguishable.

3. **Anopheles (Anopheles) plumbeus,** Stph. (fig. 2, a).

Anopheles plumbeus, Stephens, Zool. Journ. iii, p. 503 (1828).
Anopheles nigripes, Staeger, Kroyer's Nat. Tidschr. ii, p. 552 (1839).

The general black colour, densely and uniformly scaled wings, white scales on front of mesonotum, conspicuously hoary stripe down centre of mesonotum, and conspicuous white frontal tuft, will suffice to distinguish this species from those with which it might be confused.

The larva and egg have been described by Lang, Eysell, and Carter and Blacklock. *A. plumbeus* is the only species in the Palaearctic fauna which is known to breed in rot-holes in trees, and the very striking characteristics of the larva all seem to be correlated with this habit. As has already been pointed out by Christophers, tree-hole larvae of different genera of mosquitos commonly show three forms of modification: (1) a reduction of the hairs on the head, and especially of the small bristles on the antennae; (2) an increase and enlargement of the hairs on the thorax and abdomen; and (3) a development of chitinous structures on the last few abdominal segments. All these points are well illustrated by *A. plumbeus*. The tree-holes in which these larvae are found are frequently (perhaps usually) dark, and it may be supposed that the sense of sight would be of little value to the inhabitants of such places, while that of touch would attain a greatly enhanced importance, since the

mosquito larvae have a number of predaceous enemies living with them. Possibly this may help to explain the development of hairs on the soft parts of the body, though their reduction on the head is not so easy to account for. The development of additional chitinous plates may be merely a chemico-physical reaction to the excess of tannin in the water.

Whatever may be the use of these larval modifications, it seems certain that they are due to environmental conditions (since they are shown by species in totally unrelated genera), and therefore the genus *Coelodiazesis*, founded solely on these characters, cannot be satisfactorily maintained.

Distribution.—Throughout Europe, wherever there are many deciduous trees, in which rot-holes can form. Not yet recorded with certainty from North Africa or Asia, except one from Katmia, Cilicia (*Lt.-Col. Lelean*, recorded by Christophers).

The Himalayan species *A. barianensis*, James, has been referred to by Christophers as identical with *A. plumbeus*, but there are small differences: in *A. barianensis* the white scales on the mesonotum extend further (almost half-way from the front) and the femora and tibiae are conspicuously white at the tips, whereas in *A. plumbeus* they have scarcely a trace of white. As there are also small distinctions between the larvae, it will probably be best to regard the two as distinct species, occupying separate geographical areas in the Palaearctic and Oriental regions. The type has also a North American representative in *A. barberi*, Coq., which is distinct from both the old-world forms, though closely resembling them.

4. **Anopheles (Anopheles) maculipennis**, Mg. (fig. 2, d).

Anopheles maculipennis, Meigen, Syst. Beschr. i, p. 11 (1818).
Culex claviger, Fabricius (*nec* Meigen), Syst. Antl. p. 35 (1805).
Anopheles occidentalis, Dyar & Knab, Proc. Biol. Soc. Wash. xix, p. 159 (1906); Howard, Dyar & Knab, Mosq. N. & C. Amer. iv, p. 1026 (1917).
Anopheles lewisi, Ludlow, Psyche, xxvii, p. 74 (1920).
Anopheles selengensis, Ludlow, Psyche, xxvii, p. 77 (1920).

This could not easily be confused with any other Palaearctic species except *A. elutus*; from this it differs in several small details of coloration, as indicated in the key. The pale area in the fringe at the tip of the wing is diagnostic of *A. maculipennis*, when it is present, but can only be seen in perfect specimens, the fringe at the wing tip being very easily denuded; moreover, the fringe is entirely dark in some individuals, and as the wing-spots also vary somewhat in intensity, the distinction between the adults of these two species is not very clearly marked. Perhaps the best distinction between the two species is in the colour of the scutum, that of *A. maculipennis* having a broad brown or blackish-brown stripe on each side, as in *A. bifurcatus* and *A. plumbeus*.

According to Wesenberg-Lund the Southern European race of *A. maculipennis* is smaller than the Northern. The difference, if it exists, is very slight, and is only to be found in the *average* measurement, since many Mediterranean specimens which I have seen are quite large. Dyar (in correspondence) also maintains that there is a minute difference in the hypopygia between specimens from France and Siberia and those from Hungary. I am unable to confirm this, and consider that the small amount of variation which does occur is individual only. Mounts of male hypopygia of specimens from Britain, Macedonia and Constantinople show no difference whatever.

In my opinion the Western North American *A. occidentalis* is specifically identical with *A. maculipennis*. I can discern no difference in the larvae; the adults are alike in all external features, and the only demonstrable difference in the male hypopygia is that the two outer spines on the claspette are both pointed in *A. occidentalis*, while one or both of them are blunt-ended in *A. maculipennis*. Such a distinction seems to me inadequate even for varietal separation. The egg of *A. occidentalis* is as yet undescribed, and may differ from that of *A. maculipennis*, but

I do not anticipate that such will be found to be the case. In any event *A. occidentalis* is much closer to *A. maculipennis* than is the Eastern North American *A. quadrimaculatus*, which differs in larva, hypopygium, and adult coloration. This is a fact of considerable interest, and is in line with what has been found in the genus *Aëdes*.

The early stages have been described in detail by Nuttall and Shipley, Lang and others. The larvae are found most commonly in open, weedy water in low-lying districts, sometimes in brackish water near the coast.

Distribution.—Throughout Europe, from the Arctic to the Mediterranean; North-West Africa (except desert regions); and across Siberia to North-Western America; also recorded by Christophers from Upper Mesopotamia.

5. **Anopheles (Anopheles) elutus,** sp. n. (fig. 2, e).

Anopheles sp., Christophers, Ind. J. Med. Res. vii, p. 711 (1920).
Anopheles maculipennis var., Barraud, Bull. Ent. Res. xi, p. 389 (1921).

Differs from *A. maculipennis* as follows: No trace of a pale spot in the fringe at the tip of the wing, the fringe being uniformly dark. Dark spots at the bases of the fork-cells and at cross-veins very poorly developed, often hardly perceptible, especially in the male. White frontal tuft small, rather inconspicuous. General coloration of the body rather lighter than in *A. maculipennis*, the sides of the scutum not any darker than the middle. Male hypopygium apparently identical with that of *A. maculipennis* in structure, but the ninth tergite less strongly chitinised relatively to the rest of the organs. Egg without lateral float-cells, evenly fringed all round as in *A. plumbeus*, but resembling *A. maculipennis* in its more elongate shape.

Larva apparently identical with that of *A. maculipennis*.

Type, a male in the British Museum reared from larva taken in marsh at Kishon, Palestine (*Capt. P. J. Barraud*).

The credit for the recognition of this species belongs to Major Christophers, who was the first to obtain the eggs. These are so different from those of *A. maculipennis* that it is impossible to regard the two forms as varieties of one species, notwithstanding the identity of the larvae and the close similarity between the adults. Major Christophers' observation has been amply confirmed by Capt. Barraud, who reared the species in Palestine, and presented material of all stages to the British Museum.

Distribution.—Mesopotamia (*Christophers*); Palestine (*Barraud*); Syria (*Barraud*); Macedonia (*Waterston*); Cyprus (*Dr. G. A. Williamson*); Transcaspia (Amudaria, *C. Ahnger*, in coll. Helsingfors Mus.); West Caspian (Adzikabul, near Baku, *per Col. Wenyon*); Steiermark (Admont, *Strobl.*; in coll. *L. Oldenberg*); W. Persia (Quritu, *H. E. Shortt*).

In Palestine, Lower Mesopotamia and Transcaspia this species entirely replaces *A. maculipennis*, but in Macedonia the two occur together. *A. elutus* appears to be absent from Central and Northern Europe.

6. **Anopheles (Anopheles) lindesayi,** Giles.

Anopheles lindesaii, Giles, Gnats, p. 166 (1900).

A very well-marked species, with no close ally, unless the Japanese and Formosan forms are regarded as distinct. In several respects it is intermediate between the *Anopheles* and *Myzorhynchus* groups; the transition is perhaps made more complete by *A. gigas*.

A. lindesayi is usually found at high altitudes and breeds in mountain streams. According to Christophers' description and figure the ninth tergite of the male hypopygium is broad and shield-like, but in the Japanese male I have examined it has the usual narrow form, a narrow, curved strip, the ends being pushed out but

not forming definite processes. This may perhaps indicate a specific difference from the Indian form, though I cannot find any other characters in the adult to support such a conclusion.

This is possibly the so-called new species recently recorded (but not named) from Japan (see Tropical Diseases Bulletin, xvi, 1920, p. 106).

Distribution.—Mountains of India; Formosa (*Koidzumi*); Japan (Nagasaki, *Lamborn*).

7. **Anopheles (Anopheles) punctibasis,** sp. n.

Closely related to *A. hyrcanus* (Pall.), but differs in the following particulars:—Average size somewhat larger (♂ 4·5 mm., ♀ 5·5 mm. in length of wing); wings more distinctly mottled in naked-eye appearance than in the most brightly-marked *A. hyrcanus*. Antennae slightly but distinctly more slender than those of *A. hyrcanus* except for the first joint, which is distinctly stouter. Scales of antennae light brown and confined to the torus and the first two flagellar joints (in *A. hyrcanus* they are white and extend to the fourth or fifth flagellar joints). Palpi normally entirely black-scaled. All the tibiae, the first three joints of the front and middle tarsi, and the first four joints of the hind tarsi, narrowly but distinctly whitish-ochreous at the base as well as at the tip. A white dot at the extreme base of the costa, and a second immediately beyond the humeral cross-vein. Dark and light areas on veins sharply defined, no intermixture of light and dark scales except to a very slight extent on the third vein. Processes of ninth tergite of male hypopygium very short and broad, almost semicircular in form (hypopygium otherwise much like that of *A. hyrcanus*).

Distribution.—Japan: Nagasaki, 8–19.v.1921, 2 ♂ (including type), 5 ♀ reared from pupae found in a muddy shaded pool in company with *Culex hayashi*; Yokohama, vi.1921, 1 ♀ reared from larva (*Dr. W. A. Lamborn*).

The sum of the characters enumerated above seems to be quite sufficient to distinguish this form specifically from *A. hyrcanus,* though the close relationship is evident. The black-scaled palpi at first sight afford an easy means of distinction, but the Yokohama specimen has narrow white rings at the articulations and a distinct white tip to the last joint.

8. **Anopheles (Anopheles) hyrcanus,** Pallas (fig. 2, f).

Culex hyrcanus, Pallas, Reise durch versch. Prov. d. Russ. Reichs. i, p. 475 (1771).
Anopheles sinensis, Wiedemann, Aussereurop. zweifl. Ins. i, p. 547 (1828).
Anopheles pictus, Loew, Dipt. Beitr. i, p. 4 (1845).
Anopheles pseudopictus, Grassi, Atti R. Acc. Lincei, Rendic. viii, 1, p. 102 (1899).
Anopheles sinensis var. *mesopotamiae,* Christophers, Ind. J. Med. Res. iii, p. 196 (1916).

Easily distinguished from all other species in the Palaearctic fauna, except *A. punctibasis* and *A. mauritianus,* by the distinctly swollen front femora. This character was pointed out by Loew in his description of *A. pictus,* and together with the shaggily-scaled female palpi forms the best distinguishing mark of the *Myzorhynchus* group, the character of the ventral scale-tuft, on which the group was originally founded, being quite unreliable. The relation with the *Anopheles* group (in the strict sense) is however, obviously close; there is no definable difference in the larvae or hypopygia, and the colour differences are bridged by such species as *A. gigas.* I therefore do not admit *Myzorhynchus* as a distinct subgenus.

A. hyrcanus is a variable species in many respects, and shows a strong tendency to the production of local races. In the Oriental region some of these may be said to have reached specific differentiation (*e.g., A. separatus,* Leic.), but this can hardly be said of the Palaearctic forms, at least with our present knowledge of them.

Christophers seems inclined to distinguish the var. *mesopotamiae* on account of a slight difference in the shape of the processes of the ninth tergite of the male hypopygium, but this distinction is no more constant than the colour characters which he adduces to separate *mesopotamiae* from *hyrcanus*. The form inhabiting Japan and Eastern Siberia has the wing-markings blurred somewhat as in the var. *mesopotamiae*, but the general coloration is much darker. The var. *pseudopictus* is at first sight sharply distinguished by its pale fourth hind tarsal joint (one Macedonian example has the third joint also broadly white at the tip), but the paleness in some specimens is only visible in certain lights, and there appears to be no other distinction between the two forms. The fifth hind tarsal joint in *pseudopictus* remains dark, but in Swellengrebel's *argyropus* from Sumatra both the fourth and the fifth joints are white; this condition seems to have been developed independently in *argyropus* and *mauritianus*, and, if so, *argyropus* should perhaps be regarded as an extreme form of *hyrcanus* rather than as an Oriental form of *mauritianus*.

A. hyrcanus is found chiefly in large marshes, especially near the sea. The larva has been described by Joyeux.

Distribution.—North Mediterranean coast from the Rhone delta to the Levant, and across Central Asia from the Black Sea coasts to Japan; also (in a darker variety) throughout the Oriental region. The var. *mesopotamiae* appears to be confined to the region at the head of the Persian Gulf; the var. *pseudopictus* has been found in Italy (*Grassi*); Macedonia (*Waterston*); Danube delta (*Leon*); Transcaspia (Tedjen, *C. Ahnger*).

9. **Anopheles mauritianus**, Grp.

Anopheles mauritianus, Grandpré, Planters' Gazette Press (1900).
Anopheles paludis, Theobald, Royal Soc., Rept. Malaria Com. p. 75 (6th July, 1900).

This is the African representative of *A. hyrcanus*, from which it differs almost solely in the generally blacker colour and the white tip of the hind tarsus. The range of variation of the two forms is, however, quite distinct, and it is no doubt justifiable to regard them as separate species. Christophers distinguishes the hypopygium from that of *A. hyrcanus* by the absence of leaflets on the aedoeagus, but either he was mistaken in his observation or the species is variable in this respect, since delicate leaflets are certainly present in those which I have examined.

Like its ally *A. hyrcanus*, this species lives chiefly in large swamps, especially near coasts, and is a poor carrier of malaria.

Distribution.—Tropical Africa, extending into the Palaearctic region only in the south-eastern Mediterranean, where it occurs in the Nile delta and in the marshes on the Palestine coast (*Barraud*).

Subgenus **Myzomyia** (Blanchard), Christophers.
Ind. Journ. Med. Res. iii, p. 383 (1915).

Adult.—Cross-veins and bases of forks of wing-veins with light scales (except in *A. rhodesiensis*). Costa with four or more pale spots. Male hypopygium with a group of several (4–6) stiff bristles at the base of each side-piece, none of which are borne on tubercles or otherwise differentiated. Prosternal hairs nearly always reduced.

Larva.—Shaft of antenna without a branched hair. Leaflets of palmate hairs generally with long terminal filament. Internal clypeal hairs rather wide apart.

The members of this subgenus, though showing a great total range of ornamentational characters, are really all much more closely allied than the species of the subgenus *Anopheles*. The male hypopygia are almost identical throughout the subgenus, the minute distinguishing characters given by Christophers being in some

cases of very uncertain value; the species most easily recognisable as regards hypopygial structure are those (*pulcherrimus, multicolor*) which have no leaflets on the aedoeagus, but it is impossible to consider a common lack of these structures as indicating relationship. The larvae also are extremely similar and difficult to distinguish.

Adults.

1. Abdomen densely scaly; the scales forming lateral tufts on each segment; last hind tarsal joint white; female palpi shaggily scaled .. 2
   Abdomen without lateral scale-tufts; last hind tarsal joint dark; female palpi with most of the scales appressed 3
2. Fourth hind tarsal joint all white .. .. .. *pulcherrimus*, Theo.
   Fourth hind tarsal joint mostly dark .. .. *pharoensis*, Theo.
3. Femora and tibiae pale-spotted 4
   Femora and tibiae not pale-spotted; abdomen without scales 5
4. Abdomen scaly almost to the base .. .. *stephensi*, Liston.
   Abdomen without scales, except on cerci .. .. .. *costalis*, Theo.
5. Pale wing-markings confined to costa and first vein .. ..*rhodesiensis*, Theo.
   Pale markings on all wing-veins 6
6. Tip of last palpal joint white-scaled 7
   Tip of last palpal joint black-scaled 8
7. Thorax with hairs only; last two white rings of female palpi quite narrow .. .. *sergenti*, Theo.
   Thorax with narrow scales as well as hairs; last two white rings of female palpi rather broad .. .. *superpictus*, Grassi.
8. Thorax with hairs only; male aedoeagus with leaflets (*turkhudi*, Theo.), *hispaniola*, Theo.
   Sides of mesonotum with distinct narrow scales 9
9. Male aedoeagus with leaflets .. .. *turkhudi* var. *persicus*, n.
   Male aedoeagus without leaflets .. .. *multicolor*, Camb.

Larvae.

1. Outer clypeal hair branched 2
   Outer clypeal hair simple 3
2. Palmate tufts on abdominal segments i–vii; outer clypeal hair thickly branched .. ..*pharoensis*, Theo.
   Palmate tufts on abdominal segments iii–vii; outer clypeal hair less branched .. .. *pulcherrimus*, Theo.
3. A rudimentary palmate tuft on first abdominal segment *costalis*, Theo.; *rhodesiensis*, Theo.
   This tuft absent 4
4. Posterior clypeal hair short; innermost shoulder-hair much branched *stephensi*, Liston.
   Posterior clypeal hair long 5
5. Innermost shoulder-hair much branched, plumose .. *superpictus*, Grassi.
   Innermost shoulder-hair slightly branched towards tip *multicolor*, Camb.; ? *hispaniola*, Theo.; ? *turkhudi*, Theo.

Good distinctions between some of the above larvae have yet to be discovered; possibly some may be found in the markings of the head. The larvae of *A. rhodesiensis*, *A. hispaniola* and *A. turkhudi* have not been fully described, and the British Museum does not possess sufficient material from which to supplement the descriptions.

10. **Anopheles (Myzomyia) pulcherrimus,** Theo. (fig. 2, g).

Anopheles pulcherrimus, Theobald, Proc. R. Soc. lxix, p. 369 (1902).

A very well-marked species, easily distinguished from all others in the Palaearctic fauna, except *A. pharoensis,* by having the abdomen densely covered with broad flat scales, rather loosely applied and forming distinct lateral tufts. The front femora are slightly swollen near the base, and in this point, as well as in the shaggily scaled female palpi, *A. pulcherrimus* and *A. pharoensis* seem to show some approach to *A. hyrcanus*; but the type of wing-markings and the structure of the male hypopygium are typical of the subgenus *Myzomyia.*

The early stages have been described by Vassiliev.

Distribution.—Semi-arid regions of south-western Asia, from Turkestan and the Punjab to Lower Mesopotamia.

11. **Anopheles (Myzomyia) pharoensis,** Theo.

Anopheles pharoensis, Theobald, Mon. Cul. i, p. 169 (1901).
Anopheles maculicosta, Becker, Mitt. Zool. Mus. Berlin, ii, p. 69 (1903).

Very similar to *A. pulcherrimus,* but is somewhat larger and has a broad dark ring on the fourth hind tarsal joint; usually also there is a pair of conspicuous black spots about the middle of the mesonotum, which are not seen in *A. pulcherrimus.* In both species the wing-membrane is deeply stained in the areas occupied by the main patches of dark scales. A similar condition is seen in some American species, and to some extent discounts Christophers' theory that all the pale markings of *Anopheles* wings arose by bleaching from a primitive, uniformly dark condition.

Distribution.—Essentially an Ethiopian species, being widely spread, though not common, in tropical Africa, and occurring in Madagascar. Common in Lower Egypt, and occurring rarely in Palestine (*Barraud*).

12. **Anopheles (Myzomyia) stephensi,** Liston (fig. 2, h).

Anopheles stephensi, Liston, Ind. Med. Gaz. xxxvi (1901); Christophers, Ind. J. Med. Res. iii, p. 481 (1916).

The femora and tibiae are conspicuously spotted with white, and the abdomen is almost covered with scales; the scales are narrow, and less dense than those of *A. pharoensis* and *A. pulcherrimus,* and never form lateral tufts. None of the allied Oriental or Ethiopian species (*A. maculatus, A. willmori, A. maculipalpis, A. theobaldi,* etc.) appear to have occurred within the area under discussion, and *A. stephensi* need not therefore be compared with them for our present purpose.

Distribution.—An Indian species occurring in a localised area round Basra, at the head of the Persian Gulf (*Barraud* and *Christophers*).

13. **Anopheles (Myzomyia) costalis,** Theobald (fig. 2, i).

Anopheles costalis, Theobald, Mon. Cul. i, p. 157 (1901).
? *Anopheles costalis,* Loew, Berlin. ent. Zeitschr., x, p. 55 (1886).
Anopheles arabiensis, Patton, J. Bombay Nat. Hist. Soc. xvi, p. 625 (1905).

The spots on the femora and tibiae vary in number and intensity, but are always present, and together with the absence of abdominal scales render the species an easy one to identify when Palaearctic forms alone are considered. The female palpi have three whitish rings, the terminal one broad and including the whole of the last joint.

I am informed by Dr. Enderlein that Loew's type of *A. costalis* is not now in his collection in the Berlin Zoological Museum.

Distribution.—S. Spain (*Macdonald*); Algeria (*Sergent*); S. Tunis (Tamerza, *Dr. M. Langeron*). Does not appear to occur in Egypt or Palestine.

References.—Sergent (Ed. & Et.), Ann. Inst. Pasteur, xix, 1905, p. 144; xx, 1906, p. 393.

18. **Anopheles (Myzomyia) turkhudi** var. **persicus,** nov.

The type male of *A. turkhudi* has no scales on the scutum, and has distinct leaflets on the aedoeagus. The same is true of all specimens I have seen from the Punjab, but a number sent me by Christophers from East Persia show distinct scales on the scutum, and are in fact indistinguishable externally from *A. multicolor*. They can hardly be that species, however, since the male aedoeagus bears distinct leaflets, as in *A. turkhudi* and *A. hispaniola*. Provisionally, therefore, I regard them as representing a distinct variety of *A. turkhudi*, which inhabits adjacent areas in the Punjab. The real relationships of all these forms can only be determined by a close study of their habits, early stages and distribution, and the early stages of this Persian form are not yet recorded.

19. **Anopheles (Myzomyia) multicolor,** Camb. (fig. 2, k).

Anopheles multicolor, Camboulin, C. R. Acad. Sci. cxxxv, p. 704 (1902).
Pyretophorus chaudoyei, Theobald, Mon. Cul. iii, p. 68 (1903).
Pyretophorus cleopatrae, Willcocks (*nom. nud.*).
Anopheles impunctus, Dönitz, Zeitschr. f. Hygiene, xli, p. 67 (1902).

The adult does not differ appreciably from *A. hispaniola* and *A. turkhudi* except in having scales on the mesonotum (these scales, however, varying in number, width, and distinctness), and in the entire lack of leaflets on the male aedoeagus. *A. superpictus* has a similar thoracic ornamentation, but can easily be distinguished by its white-tipped palpi. Egyptian specimens commonly have the wings more extensively dark than those from Algeria, but, on the other hand, it is almost certain that Dönitz's *A. impunctus*, described from an abnormally pale specimen, is only a variety of this species.

The larva has been fully described by Foley (1912) and Langeron (1918). According to Langeron's figures the innermost shoulder-hair is only trifid at the tip, but in a number of specimens he has sent me from Tozeur, as well as in some skins sent by Capt. Barraud from Palestine, it is branched almost from the base and somewhat plumose. The head of the larva is extremely dark, the usual markings being all fused in most specimens into a large black patch which occupies the greater part of the head, leaving the front of the clypeus yellowish. The lower surface of the head, as well as the upper, is mainly blackish.

The egg as described and figured by Foley (reproduced in fig. 2, k) is very distinctive, and quite unlike that of *A. hispaniola* or *A. turkhudi*. The species is said to breed in highly saline desert pools, or in brackish water near the sea.

Distribution.—Desert regions of North Africa from Southern Algeria to Egypt; Palestine; Teneriffe. Not certainly known from further east or north.

Tribe Culicini.

I propose to revert to the old classification of mosquitos, and recognise only two tribes, the Anophelini and Culicini, including in the latter the Megarhinini and Sabethini. I am now convinced that Howard, Dyar and Knab were right in including *Megarhinus* in the Culicini and placing it somewhere near *Psorophora*; the modifications of the adults, though striking, are not fundamentally important. On the other hand, I am equally convinced that the tribe Sabethini cannot be maintained. Every character on which it has been attempted to define it breaks

down at some point or other. The character finally adopted by Howard, Dyar and Knab, that of the head bristles, is not indicated in *Eretmopodites*, which is unquestionably a Sabethine genus, while it is shown in some Culicine genera, notably *Megarhinus*. There is, no doubt, a group of genera (or more probably two or three independent groups) which are more closely related to one another than to other Culicines, but in adult structure there is certainly no hard and fast line to be drawn. In regard to the absence of the anal brush of the larva, which is the one common and outstanding feature of all SABETHINI, Colonel Alcock has suggested to me (I consider with great plausibility) that this may be an adaptive character, and therefore not necessarily indicative of relationship. As he points out, larvae living in small confined spaces, as do almost all of the SABETHINI, would not require the anal brush for swimming; and as it is absent in the first stage, there seems no reason whatever why its development should be proceeded with in the later stages. In confirmation of this view, it may be remembered that some of those species of *Aëdes* (*Stegomyia*) which live in small collections of water have the brush much less developed than in the free-living forms.

The ancestral form probably had pulvilli and spiracular bristles, narrow scales, and a non-carnivorous larva; partaking thus of some of the characters of *Theobaldia* and *Lutzia*; no such form is known, however.

Table of Genera of Palaearctic Culicine Mosquitos.

Adults.

1. Vein A_n (6th) ending below or a little before the level of the base of R_s (2nd); no microtrichia on wing-membrane .. .. *Uranotaenia.*
   Vein A_n ending well beyond the level of the base of R_2; wing membrane with microtrichia 2
2. Pulvilli absent 3
   Pulvilli present 9
3. Spiracular bristles present 4
   Spiracular bristles absent 6
4. Proboscis slender, flexible, as long as the whole body; one pro-epimeral bristle (or none); no sternopleural bristles.. .. .. *Rachionotomyia.*
   Proboscis otherwise; sternopleural bristles present 5
5. Proboscis rigid, hooked; no pro-epimeral bristles; cell R_2 extremely short; a V-shaped thickening of the wing-membrane between veins Cu_1 and Cu_2 (forks of 5th) .. .. *Megarhinus.*
   Proboscis flexible, straight in repose; several pro-epimeral bristles; cell R_2 long; no V-shaped thickening of wing-membrane.. .. *Theobaldia.*
6. Two pro-epimeral bristles .. .. *Orthopodomyia.*
   Several (about 5) pro-epimeral bristles 7
7. No post-spiracular bristles; female claws simple *Taeniorhynchus* (subgenus *Coquillettidia*).
   At least a few small post-spiracular bristles present; female claws nearly always toothed 8
8. Proboscis not very stout, straight or curved upwards in repose.. *Aëdes.*
   Proboscis stout, apparently (from dry specimens) curved downwards in repose .. .. *Armigeres.*
9. Lower mesepimeral bristles numerous.. .. .. *Lutzia.*
   Normally one lower mesepimeral bristle; often none, but very rarely two or three .. .. *Culex.*

Larvae.

1. Anal brush and barred area absent; thorax with a strong spine at each posterior corner .. .. *Rachionotomyia.*
   Anal brush and barred area present (except in first stage) 2
2. Siphon with one pair of ventral tufts 3
   Siphon with several ventral tufts 9
3. Siphonal tuft at or near base 4
   Siphonal tuft near middle, or beyond 5
4. Mouth-parts modified for predacity; a chitinous plate on each side of eighth segment; body colour dark reddish .. .. *Megarhinus.*
   Mouth-parts not modified for predacity; a patch of scales on each side of eighth segment; body colour not reddish .. .. *Theobaldia.*
5. Pecten teeth rounded and fringed apically; a chitinous plate on each side of eighth segment (in fourth stage only) in addition to the comb *Uranotaenia.*
   Pecten teeth (when present) sharply pointed, with denticles on one side; eighth segment with comb or patch of scales 6
6. Valves of siphon and tracheal system highly modified for subaquatic respiration .. .. *Taeniorhynchus.*
   Valves of siphon and tracheal system not specially modified 7
7. Extremely long single hairs on thorax and abdomen, besides long hair tufts; dorsal chitinous plates on segments 6–8 in the fourth stage; colour reddish .. .. *Orthopodomyia.*
   Single hairs not longer than the moderate tufts; no dorsal chitinous plates on segments 6–8; colour not reddish 8
8. Pecten present .. .. *Aëdes.*
   Pecten absent .. .. *Armigeres.*
9. Mouth-parts modified for predacity; anal segment long and pointed *Lutzia.*
   Mouth-parts not modified; anal segment shorter and less pointed.. *Culex.*

Genus **Uranotaenia,** Arrib.

Most writers have distinguished this genus mainly by the short upper fork-cell (cell R_2), but while this is a sufficient distinction in the majority of cases, there are a few species (*e.g., U. unguiculata*) in which the shortening of this cell is not very noticeable, and, on the other hand, some species of the *Aëdes* group have the cell so short that they have been mistaken for species of *Uranotaenia*. A more absolutely diagnostic character, though requiring a high magnification for its detection, is the absence in all known species of the genus of microtrichia on the wing-membrane. This distinguishes *Uranotaenia* sharply from all other CULICIDAE. The short anal vein, ending below or before the base of the radial sector, is shown also by the tropical genera *Hodgesia* and *Harpagomyia.* In all known species except *U. unguiculata* the front claws of the male are small and equal in length. The pleural bristles are very much reduced in number, there being only one or two in each of the pronotal, pro-epimeral, spiracular and pre-alar series.

The larva is not very sharply distinguished from that of *Aëdes*, except in the fourth stage, when the characteristic lateral chitinous plates appear on the eighth abdominal segment. The spine-like frontal hairs found in many species are represented by normal simple hairs in others (*e.g., U. unguiculata*). The form of the pecten-teeth is characteristic. The resting position in the water is almost horizontal.

The genus is tropicopolitan, but two species occur within the limits of the Palaearctic region.

1. **U. unguiculata,** Edw.

Uranotaenia unguiculata, Edwards, J. Proc. Asiatic. (Soc.) Bengal, ix, p. 51 (1913).

A line of pale blue flat scales passes round the margin of the mesonotum from wing-base to neck. The front claws of the male are unequal, the larger one with a small tooth.

The larva has been described by Joyeux.

Distribution.—Eastern Mediterranean region. Originally described from North Palestine, it has since been found in Jerusalem (*Goldberg*), Egypt (*Gough*), Macedonia (*Waterston, Joyeux*), and Italy (*Hargreaves*), but is always rare.

2. **U. bimaculata,** Leicester.

Uranotaenia bimaculata, Leicester, Cul. of Malaya, p. 226 (1908).

There is no line of flat scales on the margin of the mesonotum, but just in front of each wing-base is a large oval velvet-black spot on the integument. The front claws of the male are normal for the genus, small, equal and simple.

The larva is not yet described.

Distribution.—Japan (Tokio, *S. Yamada*); Malay Peninsula (*Leicester*). There is also a representative species (*U. mashonaensis,* Theo., = *U. bimaculata,* Theo.) in tropical Africa, which scarcely differs from the Oriental form. Should the two be united, the species must be known as *U. mashonaensis,* Theo.

Genus **Rachionotomyia** (Theo.) Edw.

This genus has never been fully described. I would define it as follows:—

Proboscis slender throughout; longer than the long front femora, and as long as the whole body. Mouth-parts normal; maxillary teeth very small. Palpi short in both sexes, not more than one-sixth as long as the proboscis. Female antennae slender, the verticils about four times as long as the joints; male antennae with shorter joints (except the last two) and longer verticils. Eyes practically touching above the antennae, the supra-antennal portion broad. A pair of strong bristles, placed close together, projecting forwards from immediately above the line of contact of the eyes; far away from these bristles are two other smaller ones on each side of the head. Prothoracic lobes well separated. Mesonotum with or without well-developed dorso-central bristles. One pro-epimeral bristle (even this is absent in some species). Several (3–6) spiracular bristles. No postspiracular bristles; no row of bristles on the upper part of the sternopleura; no lower meso-epimeral bristles. Sub-alar knob small, with few bristles. Postnotum bare, with a pair of slight furrows dividing it into three portions. Last segment of female abdomen blunt, very bristly. Male hypopygium: Lobes of ninth tergite elongate, with long apical bristles; side-pieces rather short, with conical, bristly claspette lobes; clasper long, terminal, with small thick terminal claw; tenth sternites split apically into several short, tergally projecting teeth, in a longitudinal row; aedoeagus very small, a simple, incomplete tube, with small parameres and sometimes apparently with some internal spines. Hind tibiae somewhat shorter than the others. Female claws simple; front claws of male unequal. Pulvilli absent. Wing-membrane with distinct microtrichia. R_s somewhat longer than $R_{2 \& 3}$; fork-cells moderately long; anal vein reaching well beyond the level of the base of R_s.

Larva (description based on a comparison of three Oriental species): Antennae short, smooth, apparently without hair on shaft. Clypeal hairs very small, simple. Posterior corners of metathorax with a long strong spine situated on a chitinous plate, without any accompanying long hairs; a similar but smaller spine towards each side of the mesothorax. First seven abdominal segments with seven pairs of strong stellate tufts (three dorsal, two lateral, two ventral). Thorax and first six

abdominal segments with long, lateral plumose hairs. Comb of eighth segment a row of stout spines, sometimes attached to a plate. Anal plate bears a comb of a few short spines. Siphon moderate, with sparse latero-ventral pecten and numerous hair-tufts or single hairs. Pupal paddles small, somewhat pointed, without fringe or terminal hair. Habitat: pitcher plants, bamboos, etc.

The genus is characteristic of the Oriental and Australasian regions, one species occurring in Japan.

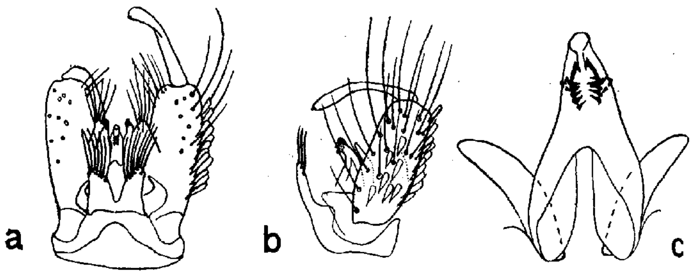


Fig. 4. Male hypopygium of *Rachionotomyia bambusa*, Yam.: *a*, ventral view, x75; *b*, lateral view, x75; *c*, aedoeagus, ventral view, x225.

Rachionotomyia bambusa, Yamada (fig. 4).

Rachionotomyia bambusa, Yamada, Dobutz. Z. Tokio, xxix, pp. 61–72 (1917).

This belongs to the rather numerous group of species with metallic silvery markings on the pleura and abdomen, and silvery spots on the femora. The chief diagnostic characters are as follows:—Head with a broad blue band in front. Prothoracic lobes with black scales. Pro-epimera with a few narrow black scales and one bristle. Mesonotum almost entirely dark brown, with long, straight, very narrow greenish-black scales. Scutellar scales broad, greenish black. Integument of pleurae mainly dark brown. Larger claw of front legs of male thick, with a pointed swelling, scarcely a tooth, beyond the middle. Lobes of ninth tergite of male each with about nine long, rather stout bristles.

I have not seen Yamada's description of the larva, and have had no specimens for examination.

Distribution.—Japan (Tokio, *S. Yamada*; Kofou, *L. Drouard de Lezey*).

Genus **Megarhinus,** R.D.

I now feel strongly inclined to accept the view of Howard, Dyar and Knab that *Toxorhynchites* should not be separated from *Megarhinus*, except as a rather weakly-marked subgenus. There are no important structural differences whatever, *Toxorhynchites* differing only in the shorter female palpi.

As Banks has pointed out, the labium in this genus is a rigid organ, and the structure of its apical part is apparently such as to prevent the possibility of the mouth-parts being used for sucking blood.

The pleural bristles in this genus are remarkable; there appear to be no true pro-epimeral bristles, but, on the other hand, a row of strong spiracular bristles is developed; there are no post-spiracular bristles, and the only bristles on the prothoracic lobes are a few which point forwards or downwards. There are only two pairs of ocular bristles instead of the usual row. The reduction of the mesonotal bristles has been remarked on by previous writers.

The presence of spiracular bristles, the close similarity in the male hypopygium, and the basally situated siphon-tuft of the larva, are points which seem to indicate some connection, distant no doubt, with *Theobaldia*, a connection which would not be suspected on a superficial examination.

The species of this genus often have very specialised habits, and these have a restricted distribution. Two species have already been recorded from the Palaearctic region; what is probably a third exists in south-east Europe.

1. **Megarhinus christophi,** Portch.

Megarhinus christophi, Portchinsky, Horae Soc. Ent. Ross. xviii, p. 122 (1884).

I do not know this species. According to Portchinsky's description it differs from *M. towadensis* in having silvery transverse bands on each of the first six abdominal segments and yellow lateral hairs on the sixth segment.

Distribution.—Amur (*Portchinsky*).

2. **Megarhinus towadensis,** Mats.

Megarhina towadensis, Matsumura, Thousand Insects of Japan, Add, ii, p. 445 (1916).

This is very much like the common Oriental *M. regius* (Tennent), but there are differences, evidently of specific value. The only specimen I have seen is one sent for determination from the Paris Museum by M. Séguy. This agrees with Matsumura's description, except that the narrow white ring on the first joint of the middle tarsus is close to but not at the base (the front legs are missing). The thorax is much rubbed, but the remaining mesonotal scales are metallic emerald green, quite unlike the dull scales of *M. regius*. The abdominal tuft is large and conspicuous, the long hair on the sixth and seventh segments black, on the eighth segment orange. The venter is mainly shining blue, but there are lateral yellow patches on sternites two, three and six, and sublateral, elongate yellow triangles on sternites four and five.

Distribution.—Japan (Towada, *Matsumura*; Kofou, *L. Drouart de Lezey*, 1906).

3. **Megarhinus** sp.

It is necessary to mention here a *Megarhinus* larva which was obtained near Karasouli, Macedonia, by Capt. Waterston.

The specimen was taken with a number of other larvae of different insects which were thought to be preying on mosquito larvae. It was not identified until after the collector's return to England, and no attempt was made at the time to rear it or to obtain others. It differs only in minute characters from the larvae of the African *M. brevipalpis*, the Oriental *M. regius*, and the North American *M. rutilus*, and it is therefore impossible to say whether it belongs to one of these species, or to some other, perhaps undescribed, form.

Genus **Theobaldia,** Neveu-Lemaire.

The two characters on which most writers have based their conception of this genus—the spotted wings and the position of the cross-veins in a straight line or nearly so—are both worthless for purposes of definition. In *T. longiareolata* and in the subgenus *Culicella* the cross-veins are well separated; while, on the other hand, in *Lutzia vorax* and occasionally in some other species (*e.g.*, *Culex tipuliformis*, *Aëdes rusticus*) they are practically in a straight line. The female palpal character on which Neveu-Lemaire founded the genus is of even less value. In one point, however, the adults do seem to be sharply distinguished from most other genera of the tribe CULICINI. This is in the possession, immediately in front of the prothoracic

spiracle, of a row of yellow bristles.* These bristles are quite apart from the usual pro-epimeral bristles, which are present in *Theobaldia* but somewhat reduced in length, their place being largely taken by the spiracular bristles, which are placed in a close-set row on the posterior side of the posterior ridge of the pro-epimeron. As in *Orthopodomyia*, there are no post-spiracular bristles.

The African species, *Leptosomatomyia fraseri*, shows the same pleural and hypopygial characters as *Theobaldia*, and should probably be included here. Apart from this, the genus is practically confined to the temperate regions of the northern hemisphere, three species occurring in the Punjab.

The larvae are sharply distinguished from others in the Palaearctic fauna (except *Megarhinus*) by the basally situated hair-tuft on the siphon.

Three subgenera (*Theobaldia*, *Culicella* and *Allotheobaldia*) are sharply defined by larval structure, but the distinction in the adults is not so clear, and it will therefore be best to tabulate all the species together, while admitting the subgenera as valid. I agree with Brolemann that *Culicella* is not generically separable from *Theobaldia*.

Adults.

1. Thorax with rather sharply defined white lines; femora and tibiae striped and spotted; costa largely pale-scaled; male palpi shorter than the proboscis (subgenus *Allotheobaldia*) .. .. *longiareolata*, Macq.
   Thorax without sharply defined white lines; femora and tibiae not striped; costa all dark; male palpi longer than the proboscis .. 2
2. Cross-veins in a straight line, or nearly (subgenus *Theobaldia*) 3
   Cross-veins well separated; tarsi with narrow pale rings embracing both ends of joints; wings not distinctly spotted (subgenus *Culicella*) .. 6
3. Tarsi entirely dark; wings not distinctly spotted .. *glaphyroptera*, Schin.
   Tarsi broadly ringed with white at the bases of the joints; wings more distinctly spotted (at least in the female) by accumulation of scales at the bases of the fork-cells and on the cross-veins 4
4. Femora without pale pre-apical ring; hind metatarsi without white ring in the middle .. .. *alaskaensis*, Ludlow.
   Femora with pale pre-apical ring; hind metatarsi with white ring in middle 5
5. Wing-spots distinct; abdomen conspicuously banded with black and white .. .. *annulata*, Schrank.
   Wing-spots indistinct, especially in the male; abdominal scales nearly all ochreous .. .. *subochrea*, Edw.
6. First joint of front tarsi of male longer than the remaining joints together; proboscis of female almost entirely black .. *morsitans*, Theo.
   First joint of front tarsi of male not longer than the remaining joints together; proboscis of female with many pale scales at the sides and beneath .. .. *fumipennis*, Steph.

Male Hypopygia.

1. Ninth tergite with a pair of long processes; aedoeagus remarkably large and complicated .. .. *longiareolata*, Macq.
   Ninth tergite without distinct processes; aedoeagus normal 2
2. Clasper somewhat swollen at the tip; side-piece with a subapical projection bearing a number of long, flattened appendages .. *glaphyroptera*, Schin.
   Clasper not swollen at the tip; side-piece otherwise 3
3. Side-piece with a more or less distinct, hairy subapical knob 4
   Side-piece without subapical knob or agglomeration of hairs 5

* This character is also possessed by *Megarhinus*, *Psorophora* and some Sabethine genera (*e.g.*, *Rachionotomyia*), but none of these could well be confused with *Theobaldia*.

4. Tip of eighth sternite with a close-set row of short spines *alaskaensis*, Ludlow.
   These spines absent .. .. .. *annulata*, Schrank.; *subochrea*, Edw.
5. Side-pieces barely three times as long as their basal width; tip of eighth sternite without row of spines .. .. *morsitans*, Theo.
   Side-pieces four times as long as their basal width; tip of eighth sternite with row of short spines .. .. *fumipennis*, Steph.

Larvae.

1. Antennae short, with small hair-tuft or a single hair; siphon short, at most three times as long as broad 2
   Antennae long, with large, many-branched tuft; siphon long, at least five times as long as broad (subgenus *Culicella*) 3
2. Siphon with 6–10 stout, widely-spaced spines (subgenus *Allotheobaldia*) *longiareolata*, Macq.
   Siphon with a well-marked pecten, most of the teeth of which have their tips drawn out into long hairs (subgenus *Theobaldia*) *annulata*, Schrank; *subochrea*, Edw.
3. Pecten straighter; siphon without accessory spines .. *morsitans*, Theo.
   Pecten oblique; siphon also with accessory spines .. ..*fumipennis*, Steph.

The larvae of *T. glaphyroptera* and *T. alaskaensis* are unknown.

Subgenus **Allotheobaldia**, Brolemann.

1. **Theobaldia (Allotheobaldia) longiareolata** (Macquart).

Culex longiareolatus, Macquart, Dipt. Exot. i, 1, p. 34 (1838).
Culex spathipalpis, Rondani, Bull. Soc. Ent. Ital. iv, p. 31 (1872).
Culex serratipes, Becker, Mitt. Zool. Mus. Berlin, iv, p. 78 (1908).
Culex annulatus var. *marocanus*, d'Anfreville, Bull. Soc. Path. Exot. ix, p. 140 (1916).

A very distinct species, which could not be confused with any other, either in the adult or larval state. The larva has been fully described by Langeron.

Distribution.—Throughout the Mediterranean region and in most of the Atlantic islands; spreading southwards by East Africa as far as the Cape Province, and eastwards through Transcaspia, Mesopotamia and Persia to the Punjab. In France it has been taken as far north as Rambouillet (*Villeneuve*), but it appears to be otherwise unknown in central and northern Europe. Some new records are: Transcaspia (Askhabad, Firudza, Vrefskaja, *Ahnger*); Seistan (*Annandale*).

Subgenus **Theobaldia**, Neveu-Lemaire.

2. **Theobaldia (Theobaldia) glaphyroptera** (Schiner).

Culex glaphyropterus, Schiner, Fauna Austriaca, ii, p. 628 (1864).
Theobaldia bergrothi, Edwards, Entom. Tidskr. p. 50 (1921).

This was described by Schiner and Ficalbi as having spotted wings, and assuming that these authors' statements indicated a definite spotting such as that of *T. annulata*, I was led to regard the specimens sent me by Drs. Bergroth and Frey as a distinct new species. Later, however, I received a series of specimens from the Vienna Museum, including some of Schiner's original series, and these showed that the spotting of the wings is really hardly distinguishable, except for a darkened area of the membrane towards the costa in the middle. The Finnish and Swedish female specimens for which I proposed the name *bergrothi* are almost certainly only *T. glaphyroptera*. On the other hand, Theobald's *Pseudotheobaldia niveitaeniata*, which I supposed in 1913 to be synonymous with *T. glaphyroptera*, is a perfectly distinct species.

T. glaphyroptera is distinct in coloration from all other European species, but is very similar to the North American *T. impatiens*, Walk., from which it differs by the very distinctive male hypopygium. The male palpi are much more slender than those of any other European species, and seem to indicate an approach to *Culex*, although the terminal joints are not upturned. The ornamentation of the thorax is variable, some specimens having a distinct pattern of ochreous or whitish lines (one straight median, and a pair of curved lateral) on a dark ground.

The larva is unknown.

Distribution.—Recorded by Schiner from Austria, and by Eckstein from the Strasburg district. The specimens I have seen are from Austria (Rekawinkel, *Pokorny*; Hammern, *Mik*; also several from Schiner's original series, collected by Egger); Moravia (Frain, *Handlirsch*); Hungary (Bartfa, *Kertész*); Sweden (Stockholm; Dalecarlia, Norrbotten, *Boheman*; Östergötland, *Haglund*); Germany(?) (Coll. Loew, Berlin Museum); Finland (Kivikoski, Saima-Canal, *Adelung*; Kuustö, *Lundström*; Kittilä, *Krogerus*; Petrosaw, *Günther*; Säräsniemi, *Wuorentaus*).

3. **Theobaldia (Theobaldia) alaskaensis,** Ludlow.

Theobaldia alaskaensis, Ludlow, Can. Ent. xxxviii, p. 326 (1906).
Culiseta siberiensis, Ludlow, Insec. Inscit. vii, p. 151 (7th Jan. 1920).
Theobaldia arctica, Edwards, Bull. Ent. Res. x, p. 136 (end Jan. 1920).

In describing *T. arctica* I compared it with *T. alaskaensis*, and suggested that the two might be the same, though according to the published figure of *T. alaskaensis* there appeared to be certain differences in the male hypopygium. Recently Dr. H. G. Dyar sent me a male from Alaska which shows that the supposed differences do not exist. The species is easily distinguished by leg markings from the other European forms, but is represented by allied species, differing in hypopygial structure, in Mexico and the Punjab.

Distribution.—I have examined specimens from Archangel; Scotland; N. England; Sweden (Norrbotten, *Boheman*; Jemtland, *Schönherr*; Stockholm, *Boheman*); Lower Austria; Upper Silesia (Astron, *Brauer*); Siberia (Irkutsk, *Ahnger*; Inserovo, 62° 5′, *Trybom*). Ludlow and Dyar record it from Eastern Siberia, Alaska and Alberta.

4. **Theobaldia (Theobaldia) annulata** (Schrank) (fig. 1A).

Culex annulatus, Schrank, Beitr. Z. Naturg. p. 97 (1776).
? *Culex variegatus*, Schrank, Enum. Ins. Austr. p. 482 (1781).
? *Culex annulatus*, de Fourcroy, Ent. Paris, p. 516 (1785).
Culex annulatus, Fabricius, Mantissa Ins. ii, p. 363 (1787).
? *Culex nicaensis*, Leach, Zool. Journ. ii, p. 292 (1825).
Culex affinis, Stephens, Zool. Journ. iv, (1825).

A common and easily recognised domestic species, normally exhibiting very little variation except in size. North European specimens are on the average larger than those from the south.

The name *Culex annulatus* was apparently proposed independently by Schrank, de Fourcroy and Fabricius, but the same species was designated in each case. De Fourcroy's diagnosis is totally inadequate, but he gives the habitat as Parisian gardens, so that he more probably had this species than an *Aëdes*.

C. variegatus, Schrank, is generally quoted as a synonym of *T. annulata*, but the inadequate diagnosis would perhaps serve better for *Aëdes lutescens*. Walker mentions specimens of *T. annulata* in the British Museum "from Dr. Leach's collection," and it is possible that these specimens (which are no longer in existence) may have been the originals of *C. nicaensis*.

The larva has been described by Langeron.

Distribution.—Throughout Europe, but probably commoner in the north than in the south, where it seems to be largely replaced by *T. longiareolata*; extending into Palestine (Jerusalem, *Dr. Goldberg*) and North Africa (Biskra, Algeria, *Eversmann*; etc.). Has not yet been found further east, but is represented in the United States by an allied species. A female in the Berlin Museum is labelled "Ural, *Eversmann*."

5. **Theobaldia (Theobaldia) subochrea,** Edw.

Theobaldia annulata var. *subochrea*, Edwards in Wesenberg-Lund, Danske Vid. Selsk. Skr., Nat. Math. Afd. (8) vii, p. 198 (1921).

Theobaldia subochrea, Edwards, Ent. Tidsk. p. 50 (1921).

? *Culex penetrans*, Robineau-Desvoidy, Mem. Soc. Hist. Nat. Paris, iii, p. 407 (1828).

Though structurally identical with *T. annulata*, this differs so conspicuously and sharply in coloration that it must be regarded as a distinct species, especially as it is not confined (as was at first thought) to desert areas, and its coloration therefore cannot be purely adaptive. The differences from *T. annulata* are as follows:—

Mesonotum with the integument lighter, the scales almost uniformly reddish brown. Abdomen almost uniformly ochreous, the dark brown scales of *T. annulata* being replaced by light ochreous brown, and the white ones by almost the same colour. Whitish lateral patches, however, remain at the base of each segment, and the basal segmental bands, as well as the median line of the second segment, can be faintly made out on account of their slightly lighter colour. Leg-markings as in *T. annulata*, but somewhat less conspicuous owing to the dark parts being somewhat lighter. Wing-spots very faint, the scales being less densely aggregated than in *T. annulata*; in the male the spotting of the wing is scarcely perceptible at all.

The larva, so far as I can see, is absolutely identical with that of *T. annulata*.

Robineau-Desvoidy's description of *C. penetrans* applies in many respects to this species, but he states that the third joint of the middle tarsi of the male is bristly, which if true, is very remarkable. The type being lost, *C. penetrans* may be left as a possible synonym of *T. subochrea*.

Distribution.—I have examined specimens from the following places:—Mesopotamia (Basra, *Capt. P. J. Barraud*; a series including the type male); Persia (Ghilan, 950 m., Calhors, *J. de Morgan*); Palestine (Jerusalem, *Dr. Goldberg*); Macedonia (Hadji Geul, *Capt. J. Waterston*); Denmark (brackish-water swamp near Copenhagen, *Dr. C. Wesenberg-Lund*); England (Earl's Court, London, *W. J. Pendlebury*). In Mesopotamia this was the only form found; in the other countries *T. annulata* was found in the same localities.

Subgenus **Culicella,** Felt.

6. **Theobaldia (Culicella) morsitans** (Theobald).

Culex morsitans, Theobald, Mon. Cul. ii, p. 8 (1901).

? *Culex flavirostris*, Meigen, Syst. Beschr. vi, p. 242 (1830).

Apart from the characters mentioned in the key, this species can generally be distinguished from *T. fumipennis* by its slightly smaller size, by the more slender and rather less hairy male palpi, and by the absence of distinct Λ-shaped black marks on the abdominal sternites in both sexes. I at one time considered that the North American *T. dyari* (Coq.) might be synonymous, but Dr. H. G. Dyar informs me that the two are distinct by hypopygial characters.

Meigen's statements concerning the proboscis and palpi of his *C. flavirostris* (male) might possibly be taken as indicating this species, but he says "Füsse ganz braun," which presumably excludes it. Like the great majority of Meigen's names, *C. flavirostris* is unrecognisable.

The larva varies in colour, but is usually dark brown or blackish.

Distribution.—Throughout Europe, from Britain and France to Finland (Sammatti, *Sahlberg*; Kuustö, *Lundström*), Petrograd (♂ in coll. *B. Lichtwardt*) and Macedonia. Not yet known from North Africa or Asia.

7. **Theobaldia (Culicella) fumipennis** (Steph.) (fig. 5c).

Culex fumipennis, Stephens, Zool. Journ. i, p. 453 (1825).
Culex ficalbii, Noé, Bull. Soc. Ent. Ital. xxxi, p. 238 (1899).
Culicada theobaldi, de Meijere, Tijd. v. Ent. liv, p. 142 (1911).

Distinguished by the characters mentioned in the keys and under *T. morsitans*.

The larva, apart from the conspicuous structural differences in the siphon, may generally (perhaps always) be distinguished in life from that of *T. morsitans* by its pale yellowish green colour. Both species are mainly bottom feeders and are generally found in shallow, weedy, stagnant water.

Distribution.—Throughout Europe, except perhaps in the far north. The material I have examined shows a range from Scotland and France to Sweden and Macedonia.

Genus **Orthopodomyia**, Theo.

This genus is well characterised in the larval state by the absence of a pecten on the siphon and the development, in the fourth-stage larva, of dorsal chitinous plates on the sixth, seventh and eighth segments of the abdomen. These two characters together will distinguish the genus from all other mosquitos. In addition there are some small peculiarities, such as the development of reddish pigment in the body of the larva, and the very long single lateral hairs on the thorax and abdomen. The adult characters are not very well marked, the most obvious being: (1) the presence of only two pro-epimeral bristles; (2) the small number of bristles on the pre-alar prominence of the pleurae; there are five or six in *O. pulchripalpis*, but the number is reduced to one or none in the tropical species, while in *Culex*, *Aëdes*, *Theobaldia* and *Taeniorhynchus* there are 12 or more; (3) the length of the first front tarsal joint, which in both sexes is distinctly longer than the remaining four together, while in most other mosquitos it is only about as long; (4) the rather long and stout antennae of the male, all the joints being longer than usual; (5) the short fourth joint of the front and middle tarsi of the female, which is much shorter than the fifth, and like that of the male, scarcely any longer than broad. The very long fork-cells and the long first hind tarsal joint are also noticeable. The hypopygial structure is practically the same as in *Theobaldia* (subgenus *Culicella*).

1. **Orthopodomyia pulchripalpis** (Rondani).

Culex pulchripalpis, Rondani, Bull. Soc. Ent. Ital. iv, p. 31 (1872).
Orthopodomyia albionensis, MacGregor, Journ. R.A.M.C. p. 451 (1919).

The beautiful pattern of narrow, pure white lines on the deep black thorax is not to be seen in any other species known from the Palaearctic region, though confusion might be possible with some Himalayan species of *Aëdes*, such as *A. pseudotaeniatus*. The entirely white terminal joint of the male palpi, and the rather long female palpi (nearly half as long as the proboscis), will distinguish it from all such species, without reference to the generic characters. The North American *O. signifer* (Coq.) is very closely allied, being structurally identical, but differing in having scattered white scales on the wings, especially a patch of white scales in the middle of the wing over the cross-veins. The Oriental species are very differently coloured.

In Ficalbi's redescription of Rondani's types he does not definitely describe the thorax, but refers to the mesonotal scales as "giallo-ottono?" I therefore at first considered that the British and Italian forms could not be the same. However,

Prof. M. Bezzi has kindly re-examined for me Rondani's types in the Florence Museum, and reports that though the thorax in both specimens is much damaged by the pin, it is black, "even deep black," and there are traces of white lines, and two white spots in the middle of the scutellum. There can therefore be little or no doubt of the identity of *C. pulchripalpis* and *O. albionensis*.

The larva lives in tree-holes, and shows the modifications commonly found in such a habitat. It has been described by MacGregor and Lang.

Distribution.—Italy; England (Epping Forest); France (near Paris, *Séguy*). The species may not be so rare as is supposed, since all the specimens so far known (with the probable exception of Rondani's types) have been obtained by rearing.

Genus **Taeniorhynchus,** Arrib.

This genus may be distinguished in the adult from *Culex* by the absence of empodia; from *Theobaldia* by the absence of spiracular bristles; and from *Aëdes* by the absence of a definite "tibial scraper" (a close-set row of bristles at the tip), by the non-retractile eighth segment of the female abdomen and the structure of the male hypopygium. The wing-scales vary greatly in width in the different species, but are nearly always broader than in *Aëdes* or *Culex*. Although no more satisfactory distinctions can be discovered in the adults, the larval siphon is so wonderfully modified that on this character the genus is extremely well marked. At the same time the larval structure of *Mansoniodes* is so nearly identical with that of *Taeniorhynchus* and *Coquillettidia* that the three are much best regarded as subgenera under the main genus *Taeniorhynchus*, in spite of some rather conspicuous differences in the adults.

The only known Palaearctic species* belongs to the subgenus *Coquillettidia*, to which belong also the North American species and the rather numerous African and Oriental species placed by Theobald in *Chrysoconops*. *Coquillettidia* differs from the other subgenera in having no post-spiracular bristles, and this affords a further distinction from *Aëdes*, in which a few of the bristles are apparently always present.

Taeniorhynchus (Coquillettidia) richiardii (Fic.).

Culex richiardii, Ficalbi, Bull. Soc. Ent. Ital. xxi, p. 50 (1889), and xxxi, p. 199 (1899).

The rather broad wing-scales and the pale ring in the middle of the first joint of the hind tarsus will distinguish this species from other mosquitos in the European fauna.

The bionomics and morphology of the early stages have been described in detail by Wesenberg-Lund.

Distribution.—Apparently occurs somewhat locally throughout Europe, except probably in the far north, and extends into Palestine. Some apparently new records are: Sweden (Småland, Stockholm, *Boheman*); Hungary (Keszthely, *Kertész*); Austria (Freistadt, *Frauenfeld*).

Genus **Aëdes,** Mg.

This genus, as a whole, is characterised as follows:—Proboscis of uniform thickness throughout. Palpi of the female less than one-quarter as long as the proboscis. Antennae distinctly plumose in the male, with the last two joints elongate; with moderately long verticils in the female, all the flagellar joints being about equal in length. Eyes distinctly separated. A continuous row of orbital bristles. Pronotal lobes widely separated. Pro-epimeral bristles about

* The South American *T. titillans* has been recorded from Rumania by Leon, but no doubt incorrectly.

4–6, in a posterior row overlapping the spiracle. Spiracular bristles absent. Post-spiracular, pre-alar, sternopleural and upper mesepimeral bristles all present and generally numerous. Postnotum without setae. Eighth segment of female abdomen retractile, a wide membrane between it and the seventh. Side-pieces of male hypopygium with a lacuna of chitinisation extending the whole length of the inner side; claspers articulating in an horizontal plane. Tenth segment with tergites feebly developed; sternites simple, without teeth or spines. Hind tibiae with the usual row of fine microscopic hairs just before the tip on the inner side, and also with a row of 7–10 longer hairs parallel with the first row and slightly more distally placed. First hind tarsal joint shorter than the tibia. Pulvilli absent. Front and middle claws of female nearly always toothed. Cell R_2 (upper fork-cell) seldom much longer than its stem. Vein A_n (sixth longitudinal) terminating distinctly beyond the level of the base of R_3 (second vein). Distinct microtrichia on wing-membrane.

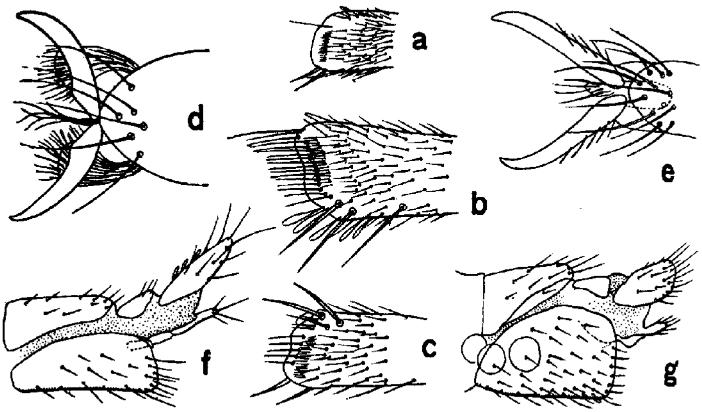


Fig. 5. Structural details of Culicidae: a, tip of hind tibia, seen from the inner side, of *Culex hortensis* (scales omitted), ×65; b, the same structure in *Aëdes lepidonotus*; c, the same in *Theobaldia fumipennis*; d, tip of last tarsal joint of *Lutzia vorax*, showing claws, empodium and pulvilli, ×340; e, tip of last tarsal joint of *Theobaldia annulata*, showing claws, small empodium, and absence of pulvilli, ×340; f, tip of abdomen of *Aëdes lepidonotus* ♀, showing slender eighth segment with narrow sternite, ×40; g, the same, *Aëdes geniculatus* ♀, showing stouter eighth segment with broader sternite.

Larva.—Mouth-parts not specially modified for predaceous habits, but the inner hairs of the mouth-brushes are generally more or less serrate. Antennal tuft generally at or before the middle. Abdomen without chitinous plates except for the anal saddle, and sometimes small plates at the bases of the thoracic hairs. Eighth segment with a lateral comb or patch of scales. Siphon unmodified, short and stout, at most four times as long as its breadth at the base, provided with a well-developed pecten and a single pair of ventral hair-tufts, situated about or beyond the middle; only very exceptionally with accessory dorsal hairs or hair-tufts.

As pointed out by Dyar (Insecutor Inscitiae, vi, p. 71, 1918) the genus can be divided into two main groups, on the presence or absence of distinct claspettes in the male hypopygium (the term claspette in this connection signifying a definite structure separated from the base of the upper flap of the side-piece, and terminating in a flattened appendage or a more or less modified bristle). Dyar's two groups may

also be defined on the structure of the mesosome of the aedoeagus. In the group which possesses claspettes the mesosome is a simple tube, rather lightly chitinised below and at the sides, membranous above. In the other group the mesosome is a paired structure, the halves of which are more or less crenulate, spiny or brush-like. Both these distinctions are so well marked that one would expect to find corresponding distinctions in the body characters or in the larvae, but all efforts in this direction have so far been fruitless.

The first group includes the subgenera *Ochlerotatus* and *Finlaya*, and is spoken of by Dyar as the New World type—inappropriately, since it includes the majority of the European mosquitos, and has many representatives in Australia, while *Finlaya* attains its strongest development in the Oriental region. The second or Old World group (subgenera *Ecculex*, *Aëdes* and *Stegomyia*) is almost confined to the tropical and subtropical regions of the Old World.

The subgenera occurring in the Palaearctic region may be separated (as adults) by the following keys, which will not necessarily hold good for the species of other regions.

Male Hypopygium.

1. Claspettes present; mesosome an unpaired simple structure 2
   Claspettes absent; mesosome a paired, more complicated structure .. 3
2. Side-piece with more or less distinct apical and basal lobes .. *Ochlerotatus.*
   Side-piece without apical or basal lobes .. .. *Finlaya.*
3. Clasper deeply divided, placed before tip of side-piece; without articulated spine .. .. *Aëdes.*
   Clasper not divided, placed at tip of side-piece, with distinct articulated spine 4
4. Spine of clasper well before the tip .. .. *Ecculex.*
   Spine of clasper at the tip (except in *A. vittatus*) .. .. .. *Stegomyia.*

Other Adult Structures.

1. Proboscis distinctly longer than front femora; last two joints of male palpi distinctly swollen, hairy, and turned downwards 2
   Proboscis not longer than front femora; male palpi otherwise; female cerci short 4
2. Female cerci short, the eighth sternite large and prominent in repose; male palpi somewhat shorter than the proboscis .. .. .. *Finlaya.*
   Female cerci long, the eighth sternite much smaller and not prominent in repose 3
3. Male palpi longer than the proboscis .. .. *Ochlerotatus.*
   Male palpi not longer than the proboscis .. .. *Ecculex.*
4. Palpi alike in the two sexes, very short; tarsi dark.. .. .. *Aëdes.*
   Male palpi long, slender, the last two joints upturned and nearly bare; tarsi with white rings at the bases of the joints .. .. .. *Stegomyia.*

The adults of these subgenera are treated separately, but it will be more convenient to tabulate all the known larvae together, as follows :—

Key to the known Larvae of Palaearctic Species of Aëdes (*sens. lat.*).*

1. Antennal tuft represented by a single minute hair; shaft devoid of small spines; eighth abdominal segment with a well-marked comb of teeth set in a single row 2

* This key will not necessarily apply to any but fourth-stage larvae. For the characters of *A. dorsalis* and *A. intrudens* I have relied on American descriptions, and for those of *A. alpinus* on Wesenberg-Lund's description of specimens from Greenland.

Antennal tuft at least two-haired; shaft nearly always spinose; eighth abdominal segment with a patch of scales or teeth which may tend to form a single row when few in number 5

2. Antennae rather long; dorsal surface of abdomen with numerous stellate tufts (*Finlaya*) 3
Antennae short; dorsal surface of abdomen without conspicuous stellate tufts (*Stegomyia*) 4

3. Abdominal tufts composed of long, stout bristles .. .. *echinus*, Edw.
Abdominal tufts composed of shorter and much more slender bristles *geniculatus*, Oliv.

4. Comb-teeth simple .. .. *albopictus*, Skuse.
Comb-teeth with lateral basal denticles .. .. .. *argenteus*, Poiret.

5. Shaft of antenna quite bare, tuft 2–3-haired (*Stegomyia*) .. *vittatus*, Bigot.
Shaft of antenna spinose (very slightly so in *mariae*), tuft generally multiple 6

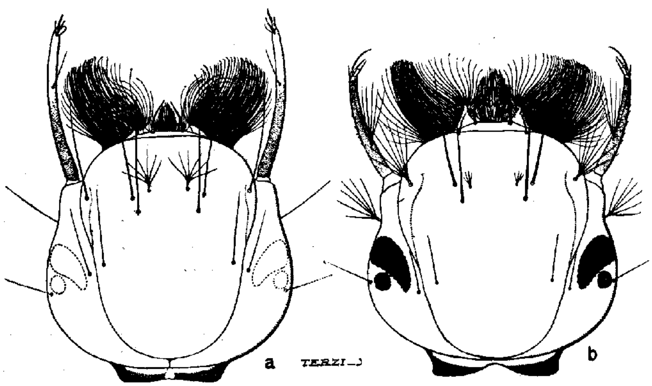


Fig. 6. Heads of larvae: a, *Aëdes echinus*, Edw.; b, *Aëdes mariae* (Serg.).

6. Pecten with detached, simple teeth outwardly; hair-tuft very small and well beyond middle of siphon; no long hairs near middle of front margin of thorax 7
Either the pecten has no detached simple teeth outwardly, or the hair-tuft is larger and situated practically at the middle of the siphon; long hair-tufts present near middle of front margin of thorax (*Ochlerotatus*) 8

7. The three post-antennal hairs (Lang) nearly in a straight line (*Aëdes*) *cinereus*, Mg.
Middle post-antennal hairs almost directly in front of the inner (*Ecculex*) *vexans*, Mg.

8. Siphon with three or four pairs of hairs on dorsal (anterior) surface *rusticus*, Rossi.
Siphon without hairs on dorsal surface 9

9. Antennae longer than the head .. .. .. *diantaeus*, H. D. & K.
Antennae shorter than the head 10

10. Siphonal index about 1·5 11
Siphonal index 2 or more; antennal spinules well-developed 12

11. Antennae almost devoid of spinules; pecten-teeth very long *mariae*, Serg.
Antennal spinules well-developed; pecten-teeth shorter .. *zammittii*, Theo.
12. Five or six small hair-tufts in anal brush before the barred area 13
At most three such tufts; siphonal index 3 or less 17
13. Siphonal index distinctly over 3; terminal teeth of pecten more or less detached 14
Siphonal index at most 3; all pecten-teeth close-set 16
14. Comb of eighth segment with 6–9 teeth in one irregular row *semicantans*, Mart.
Comb with 23–35 teeth in a triangular patch 15
15. Siphonal index about 3·2; anal gills half as long as the saddle *lutescens*, F.
Siphonal index quite 3·5; anal gills as long as the saddle .. *excrucians*, Walk.
16. Siphonal index 2·3–2·7 .. .. *annulipes*, Mg.
Siphonal index 2·6–3 .. .. *maculatus*, Mg.
17. One or two simple detached pecten-teeth beyond the siphonal tuft *cataphylla*, Dyar.
No pecten-teeth beyond the tuft 18
18. Anal gills much shorter than the saddle 19
Anal gills at least as long as the saddle 22
19. Hair-tuft distinctly beyond middle of siphon; anal gills, one-third to two-thirds as long as saddle .. .. *caspius*, Pall.
Hair-tuft practically at middle of siphon 20
20. Siphonal index 2; anal gills globular .. .. *detritus*, Hal.
Siphonal index 2·6–3 21
21. Anal gills globular, not a quarter as long as the saddle .. *dorsalis*, Mg.
Anal gills half as long as the saddle .. .. *salinellus*, Edw.
22. Comb with 50 or more scales in the patch 23
Comb with 10–20 pointed scales in the patch 24
23. Comb-scales sharp-pointed; anal gills twice as long as the saddle *pullatus*, Coq.
Comb-scales blunt-ended, fringed; anal gills about as long as the saddle *communis*, De G.
24. Last few pecten-teeth detached 25
All pecten-teeth close-set 26
25. Anal segment with a complete chitinous ring, only half as long as the gills; frontal hairs single .. .. *alpinus*, L.
Anal segment with saddle only, as long as the gills; frontal hairs branched .. .. *intrudens*, Dyar.
26. Anal segment with a complete chitinous ring, about as long as the gills *punctor*, Kirby.
Anal segment with an incomplete ring, only half as long as the gills *sticticus*, Mg.

Subgenus **Ochlerotatus**, Arrib.

Adults. Proboscis slender, distinctly longer than the front femora. Palpi short in the female; longer than the proboscis in the male (very rarely of equal length or slightly shorter), the last two joints and the tip of the long joint swollen and hairy, the last two joints turned very slightly downwards, the terminal joint generally a little more slender than the penultimate. Hair-whorls of male antennae rather irregular, the majority of the hairs projecting either dorsally or ventrally. Vertex with narrow scales only, the flat ones being confined to the sides of the head. Lower mesepimeral hairs usually (not always) present. Male hypopygium with long,

simple claspers which are provided with a terminal spine; side-pieces with well-developed basal lobes and more or less distinct apical lobes; distinct claspettes always present, terminating in a more or less flattened appendage; aedoeagus simple, the mesosome never divided into two halves. Female cerci always well-developed and long, the eighth segment small, rarely visible at all externally. All the claws of the female toothed (normally).

Larva. Antennae with a well marked hair-tuft and minute spicules on the surface. Frontal hairs generally simple or only slightly branched, the anterior pair immediately in front of the lower. Abdomen without well-marked stellate tufts; the scales of the comb of the eighth segment in a triangular patch.

This subgenus includes the great majority of the Palaearctic and Nearctic species of *Aëdes*, and attains its maximum development in the north temperate parts of these regions; it is almost or quite unrepresented in the Ethiopian and Oriental regions, but appears again with numerous representatives in southern Australia, and one or two in New Zealand. Many species also occur in the Neotropical region, and it is possible therefore that Australia was colonised by way of South America, especially as some of the South American, New Zealand and Australian species show rather marked affinities. We may perhaps assume from this that the subgenus is an old-established one.

The Palaearctic species are divisible (as adults) into three groups according to the markings of the tarsi. The first two of these groups appear to be natural assemblages of species, but the third, with dark tarsi, is less natural and shows more structural diversity. These groups may be known as the *dorsalis*-group, the *annulipes*-group and the *communis*-group; as mentioned below, *A. punctor*, though placed on account of coloration in the *communis*-group, shows signs of affinity with the *dorsalis*-group, while other members of the *communis*-group (such as *A. communis* itself) are probably more nearly related to the *annulipes*-group. The structure of the male hypopygium shows the isolated position of *A. rusticus* and *A. lepidonotus*, but suggests an affinity between *A. pullatus* and the peculiar *A. diantaeus*.

Adults.

1. Tarsi with pale rings embracing both ends of the joints, the last hind tarsal joint entirely pale (*dorsalis*-group) [compare also *Finlaya togoi*] .. 2
   Tarsi with pale rings at the bases of the joints only (*annulipes*-group) [compare also subgenera *Ecculex* and *Stegomyia*, and *Finlaya japonica*] 7
   Tarsi without pale rings (*communis*-group) [compare also subgenera *Aëdes* and *Finlaya*] 12
2. Abdomen with a pale median dorsal stripe in addition to transverse bands; sometimes entirely pale 3
   Abdomen with whitish bands at the bases of the segments only 4
3. Mesonotal scales generally fawn-coloured, with two narrow white bands running the whole length; dark and light wing-scales evenly mixed *caspius*, Pall.
   Mesonotal scales generally duller brown, with two broad, creamy bands in front; dark scales aggregated on certain veins .. .. *dorsalis*, Mg.
4. Wings and legs densely speckled with pale scales; tarsi brown with creamy rings 5
   Wings and legs only very slightly speckled; tarsi black with white rings.. 6
5. Mesonotal scales uniformly brown or fawn-coloured.. .. *mariae*, Serg.
   Mesonotum with two longitudinal bands of white scales .. *zammittii*, Theo.
6. Mesonotal scales bronzy ochreous, not forming distinct markings *pulchritarsis*, Rond.
   Mesonotum with whitish median stripe .. .. *pulchritarsis*, Rond., var.

7. Outer side of hind femora with numerous scattered dark scales; white rings of middle joints of hind tarsi less than half as long as the joints; thorax dark with some obscure paler markings .. .. *maculatus*, Mg.
Outer side of hind femora pale except towards the tip; white rings of middle joints of hind tarsi at least half as long as the joints 8

8. Costa at most with scattered pale scales; abdomen largely dark 9
Costa pale-scaled on anterior edge, at least on basal half; abdominal scales mainly or all yellow 11

9. Abdomen dark, tergites with well-defined basal white bands narrowed in the middle .. .. *semicantans*, Martini.
Abdomen with ill-defined yellowish bands and scattered yellowish scales.. 10

10. Mesonotum with a distinct broad median band of dark scales, sides yellowish; pale bands of abdomen mainly basal .. .. *annulipes*, Mg.
Mesonotum with obscure markings; pale bands of abdomen largely at apices of tergites .. .. *excrucians*, Wlk.

11. Costa yellow-scaled only on the basal half .. .. *freyi*, sp. n.
Costa mainly yellow-scaled in its entire length .. .. .. *lutescens*, F.

12. Pro-epimeral scales all flat and straight, the upper ones black .. .. *rusticus*, Rossi.
Pro-epimeral scales all ochreous, the upper ones narrow and curved .. 13

13. Postnotum with a tuft of scales .. .. *lepidonotus*, Edw.
Postnotum without scales 14

14. Wing-membrane whitish; costal scales all pale .. .. *albescens*, sp. n.
Wing-membrane not whitish; costal scales mostly or all dark 15

15. Front and middle femora conspicuously mottled in front with dark and light scales 16
Front and middle femora with only a few pale scales in front 19

16. Head and thorax with very dense bristles; integument deep black.. *alpinus*, L.
Head and thorax only moderately bristly; integument of legs paler .. 17

17. The dark parts of the abdominal tergites with scattered pale scales; male palpi usually all dark .. .. *detritus*, Hal.
The dark parts of the abdominal tergites without scattered pale scales; male palpi with a whitish ring or numerous pale scales on the long basal joint 18

18. Proboscis all dark .. .. *cataphylla*, Dyar.
Proboscis with numerous pale scales in the middle .. .. *salinellus*, Edw.

19. Hind femora pale, with a sharply defined black-scaled area at the tip *diantaeus*, H. D. & K.
Dark area at tip of hind femora much less sharply defined 20

20. Hind tibia (at least in the female) with a distinct whitish stripe on the outer side running nearly the whole length; mesonotum with white scales at the sides, blackish in the middle .. .. .. *sticticus*, Mg.
Hind tibia without whitish stripe on outer side in either sex 21

21. Scales of head and mesonotum ochreous brown, the mesonotum usually with one broad dark brown median stripe; sometimes with two ill-defined stripes, or none .. .. *punctor*, Kirby.
Scales of head and mesonotum darker brown, often mixed with white at the sides; the mesonotum usually without distinct stripes, or with two ill-defined ones 22

22. Flat scales of the head approaching the middle line .. .. *parvulus*, Edw.
Flat scales confined to the sides of the head .. .. ..*communis*, De G.; *intrudens*, Dyar; *pullatus*, Coq.

Male Hypopygia.

1. Basal lobe of side-piece bearing a row of flattened bristles or scales; terminal spine of clasper wavy .. .. *rusticus* (Rossi).
   Basal lobe of side-piece quite otherwise; terminal spine of clasper straight 2
2. Side-piece with three spines or differentiated bristles; two on the basal lobe, backwardly directed, one more distally placed and inwardly directed 3
   Side-piece with at most two differentiated bristles on the basal lobe .. 5
3. Side-piece swollen in the middle, where it has a large inwardly-directed hair-tuft .. .. *diantaeus*, H. D. & K.
   Side-piece more regularly shaped, without hair-tuft in the middle .. 4
4. A distinct hair-tuft adjoining the apical lobe; stem of claspette with a distinct projection near the middle.. .. .. .. *intrudens*, Dyar.
   No definite hair-tuft adjoining the apical lobe; stem of claspette somewhat angulated but without definite projection.. .. .. *pullatus* (Coq.).

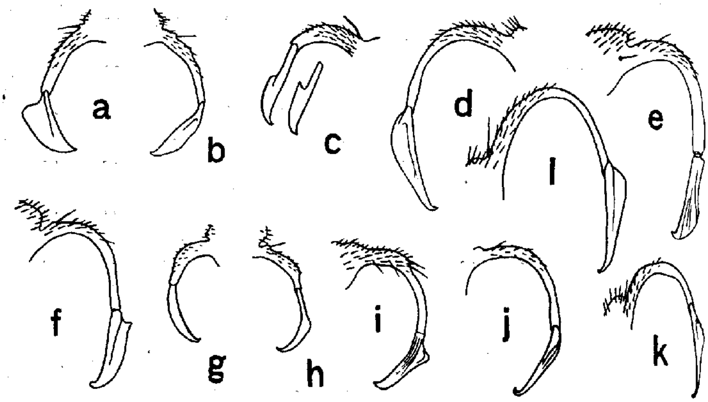


Fig. 7. Claspettes of Palaearctic species of *Aëdes*, dissected from hypopygia and drawn in side view, all × 75: a, *A. maculatus* (Mg.); b, *A. semicantans*, Mart.; c, *A. lutescens* (F.); d, *A. freyi*, sp. n.; e, *A. annulipes* (Mg.); f, *A. excrucians* (Walk.); g, *A. punctor* (Kirby); h, *A. detritus* (Hal.); i, *A. pullatus* (Coq.); j, *A. communis* (De G.); k, *A. salinellus*, Edw.; l, *A. cataphylla*, Dyar.

5. Basal and apical lobes of side-piece both very small, the latter hardly distinguishable 6
   Either basal or apical lobes, or both, quite large and conspicuous .. 8
6. Appendage of claspette short and twisted, rounded at tip *lepidonotus*, Edw.
   Appendage of claspette long, curved and pointed 7
7. Basal lobe without a spine .. .. *mariae* (Serg.); *zammittii* (Theo.).
   Basal lobe with a distinct spine .. .. .. *pulchritarsis* (Rond.).
8. Basal lobe with two spines; apical lobe ill-defined 9
   Basal lobe with at most one spine; apical lobe nearly always well-marked.. 10
9. Basal lobe very prominent (fig. 8 b) .. .. *dorsalis* (Mg.).
   Basal lobe much less prominent (fig. 8 a) .. .. .. *caspius* (Pall.).
10. Apical lobe reaching back to near middle of side-piece, and clothed with very short, curved bristles; stem of claspette short and straight .. 11
    Apical lobe not reaching so far back, and bearing longer bristles .. 12

11. Appendage of claspette three times as long as broad; basal lobe not separated from the side-piece .. .. *punctor* (Kirby).
    Appendage of claspette not much longer than broad; basal lobe separated from the side-piece in its apical portion .. .. .. *sticticus* (Mg.).
12. Basal lobe with a strong black spine and short pubescence .. *lutescens* (F.).
    Spine of basal lobe when present weaker and paler, and generally accompanied by long bristles 13
13. Basal lobe small, without spine, but a rugose area extends more than half the length of the side-piece 14
    Basal lobe larger, spine generally well-marked, rugose area not nearly reaching middle of side-piece (except in *freyi*) 15
14. Stem of claspette uniformly stout .. .. *annulipes* (Mg.).
    Stem of claspette slender apically .. .. .. *excrucians* (Walk.).
15. Stem of claspette shorter and nearly straight 16
    Stem of claspette longer and strongly curved 18
16. Appendage of claspette winged in the middle only, cylindrical on the basal third; basal lobe rather small, not pointed .. *detritus* (Hal.).
    Appendage of claspette winged for its whole length or nearly; basal lobe produced and rather sharply pointed 17
17. Basal lobe much longer than broad; appendage of claspette extremely broad .. .. *maculatus* (Mg.).
    Basal lobe scarcely longer than broad; appendage of claspette less broad *semicantans*, Mart.
18. Side-piece with short hair only 19
    Side-piece with long hair arching over the upper surface 20
19. Basal lobe large, spine present though weak .. .. *freyi*, sp. n.
    Basal lobe smaller, spine absent .. .. *parvulus*, sp. n.
20. Appendage of claspette with two slight ridges near the base *communis* (De G.).
    Appendage of claspette with one ridge or wing, which is broadest in the middle 21
21. Aedoeagus and anal segment heavily chitinised .. .. *alpinus* (L.).
    Aedoeagus and anal segment not unusually strongly chitinised 22
22. Lobes of ninth tergite with about six short straight bristles .. *cataphylla*, Dyar.
    Lobes of ninth tergite with about twelve longer bristles which curve outwards .. .. *salinellus*, Edw.

1. **Aëdes (Ochlerotatus) caspius** (Pallas) (= *dorsalis*, Theo.) (fig. 8 a).

Culex caspius, Pallas, Reise versch. Prov. Russ. Reichs. i, p. 475 (1771).
Culex punctatus, Meigen, Klass, i, p. 6 (1804).
? *Culex siculus*, Robineau-Desvoidy, Mém. Soc. d'Hist. Nat. iii, p. 406 (1827).
Culex penicillaris, Rondani, Bull. Soc. Ent. Ital. iv, p. 31 (1872).
? *Culex leucogrammus*, Loew, Zeitschr. Ges. Naturw. xliii, p. 413 (1874).
Grabhamia subtilis, Ed. & Et. Sergent, Bull. Mus. Paris, xi, p. 240 (1905).
Grabhamia willcocksi, Theobald, Mon. Cul. iv, p. 294 (1907).
Grabhamia longisquamosa, Theobald, Ann. Mus. Nat. Hung. iii, p. 102 (1905).
Mansonia arabica, Giles, J. Trop. Med. p. 130 (1906).
Culex arabicus, Becker, Denkschr. k. Ak. Wiss. Wein. lxxi, p. 140 (1910).

As has often been pointed out, this is a very variable species, particularly as regards the abdominal markings. The palest specimens have the abdominal scales uniformly ochreous, while in the darkest the median pale stripe tends to be reduced, one Hungarian specimen which I have examined showing it on the second segment only. *A. caspius* may generally be known by the bright fawn-coloured scales of the mesonotum, with two narrow longitudinal stripes of white running the whole length, and by the even scattering of the dark scales over the wing-veins, as well as by the

shape of the basal lobes of the side-pieces of the male hypopygium. The variation in the thorax is in the direction of the reduction of the white scales, which are occasionally absent, especially in the male sex, where the reduction of the white lines is often accompanied by a more or less pronounced bleaching of all the mesonotal scales. There seems to be a slight difference between the north and south European forms in coloration, the Mediterranean type being lighter than the north European, and also somewhat smaller. The difference, however, is quite indefinite, and I see no necessity for the maintenance of a varietal name. Theobald's *G. longisquamosa* was evidently described from an extremely pale specimen. The variety *hargreavesi*, Edwards (Bull. Ent. Res. x, p. 130, 1920), seems to be well distinguished by having all the scales of the female mesonotum white; it is, however, known from only a very few rather imperfect specimens.

There are two main generations in the year (in June and September), and the species is often abundant enough to cause serious annoyance. It will often migrate some miles from its breeding-places (a habit common to most salt-marsh species), and is the only *Aëdes* in the European fauna which commonly enters houses. The adults are not known to hibernate, but Dr. Langeron captured a female at Gabes in January 1919.

The larvae show the reduction in the size of the anal gills which is commonly seen in salt and brackish-water species, but they are by no means confined to saline waters, the species often spreading far up the courses of the larger rivers, breeding in open meadows. It may be that specimens from fresher water have longer gills, as these organs certainly vary in length in this species. English specimens which I have examined agree with Martini's description in having the gills about two-thirds as long as the saddle, while Capt. Barraud's Mesopotamian specimens agree with Wesenberg-Lund's description in having gills only about one-third as long as the saddle.

Distribution.—European and Mediterranean coasts; Central European plain, and eastwards to the Gobi desert; desert regions of North Africa; Palestine; Persian Gulf; Punjab, as far inland as Rawalpindi. Apparently does not extend into North America. Since the species has been so much confused with *A. dorsalis*, it may be worth while to record some of the specimens I have examined from different museums: Denmark (near Copenhagen, *Wesenberg-Lund*; Finland (Kuustö, *Lundström*); France (Bourg la Reine, *Langeron*); Germany (Usedom, Sulldorf, *Litchwardt coll.*); Austria (Vienna, *Handlirsch*; Carniola, *Loitsch*); Hungary (Neusiedler See, *Handlirsch*; Hortobagy, *Kertész*; Csepel, *Bartko*; Fehertelep, *Ujhelyi*; Iszak, *Uhl*; Torda, *Biró*); Italy (Mehadia, Livorno, Spalato, *Mann*); Roumania (Tultscha, *Mann*); Constantinople (*Paris Mus.*); Asia Minor (Fregli, Tskehir, Kara, *Lendl*); Palestine (Jerusalem, *Goldberg*); West Caspian ("Lenkoran bis Elizabetpol, 1–2 Aug. Nachts. Schrecktl. Mücken-plage," *Berlin Mus.*); Transcaspia (Aschabad, Firudza, Tedjin and Kopet Dagh, *C. Ahnger*); Gobi Desert (Cha Tcheou, Marais de Pa-hou-lian, *Dr. L. Vaillant*).

2. **Aëdes (Ochlerotatus) dorsalis** (Meigen) (*nec* Theobald et al.) (fig. 8 b).

Culex dorsalis, Meigen, Syst. Beschr. vi, p. 242 (1830).
Culex maculiventris, Macquart, Dipt. Exot. Supp. i, p. 7 (1846).
Culex curriei, Coquillett, Can. Ent. xxxiii, p. 259 (1901).
Culex onondagensis, Felt, N.Y. State Mus. Bull. 79, p. 278 (1904).
Grabhamia broquettii, Theobald, Entomologist, xlvi, p. 179 (1913).
Aëdes grahami, Ludlow, Insecutor Inscitiae, vii, p. 154 (1920).

Doubt has been expressed by Wesenberg-Lund whether this is really distinct from *A. caspius*, but I still believe that the characters I have adduced are sufficient for the separation of the two, though it must be admitted that they are both variable species with entirely similar habits, and that they are frequently found together.

The thoracic scaling (brown to dark brown central stripe on front part of mesonotum only, with a broad creamy stripe on each side of it, dark brown again on the shoulders), wing scaling (preponderance of dark scales on the first, third and fifth veins, and of pale scales elsewhere), and the prominent basal lobes of the side-pieces of the male hypopygium will render the identification of nearly every good specimen certain.

I have decided to adopt the name *dorsalis* for this species for two reasons. First, I am indebted to M. Séguy for sending me a female from Meigen's collection labelled "Culex dorsalis. Berlin," probably in Meigen's own handwriting. As *C. dorsalis* was originally described from Berlin, it seems reasonable to accept this specimen as the actual type of the species. It is in good condition, and obviously *A. curriei*, not *A. caspius*. Secondly, from the descriptions of Staeger and Zetterstedt, as well as from some examples named by Staeger which were sent me by Dr. Wesenberg-Lund, it would seem that these writers based their conception of *C. dorsalis* mainly on *A. curriei*.

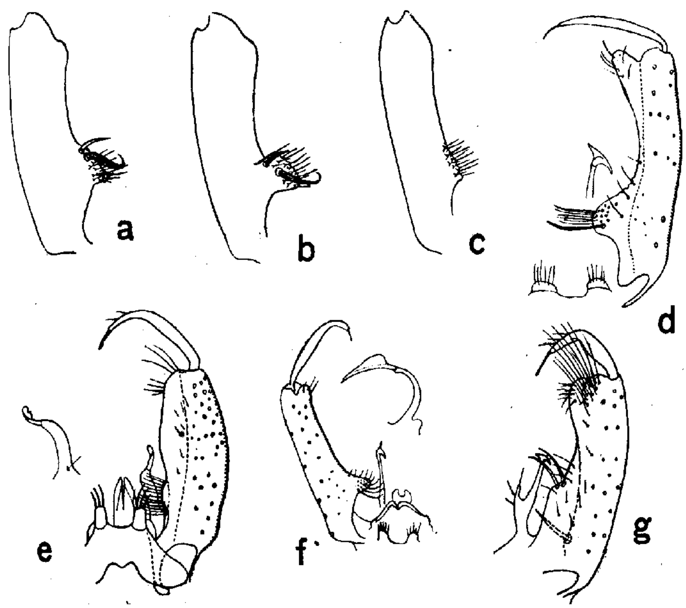


Fig. 8. Hypopygia of Palaearctic species of *Aëdes*: a, outline of side-piece, to show structure of basal lobe, of *A. caspius* (Pall.); b, the same, *A. dorsalis* (Mg.); c, the same, *A. mariae* (Serg.); d, hypopygium of *A. freyi*, sp. n.; e, hypopygium of *A. lepidonotus*, Edw., ventral view, claspette shown also in side view; f, the same, *A. parvulus*, sp. n.; g, *A. intrudens*, Dyar.

Rather contrary to expectation, Macquart's *C. maculiventris* proves to be this species and not *A. caspius*, according to the type female, which was sent me by M. Séguy.

The larva is at present only known from the description of Howard, Dyar and Knab; it has not yet been isolated in European collections. Specimens sent me by Dr. Dyar agree with the description in the monograph, and differ from *A. caspius* in at least three points: the siphon is distinctly more slender (index about 2·75 instead of about 2·3); the hair-tuft is scarcely beyond the middle of the siphon;

and the anal gills are very small and globular, not a quarter as long as the saddle. Whether these characters distinguish *A. dorsalis* as a species or merely the American race remains to be proved.

Distribution.—Coasts of northern Europe from France and southern England to Norway and the Baltic; Central European plain, and thence westward across Central Asia, China and North America as far as the Atlantic coast; North Africa (according to Macquart).

Some localities from which I have examined specimens are :—Denmark (*Wesenberg-Lund*); Sweden (Östergötland, *Haglund*); Finland (Kexholm, Eriksberg, Uskela, *E. J. Bonsd.*; Kuustö, *Lundström*; Soroka, *J. Sahlberg*); Germany (Berlin, *Meigen, Enderlein*; Usedom, Sülldorf, *Lichtwardt*; Halle, *Loew*); Austria (Hainfeld, *Mik*); Hungary (Budapest, *Kertész*; Budafok, *Bartko*; Fehertelep, *Ujhelyi*; Torda, *Biró*; Keczel, Hild, *Thalhammer*; Neusiedler-See, *Handlirsch*); North Russia (Waloniki, *Velitchkovsky*); Mongolia ("Vallée près de la Kouré de Bandie, 1500 m." and "Bords du Tarim," *Mission de Lacoste, Dr. du Chazaud*, 1909); Siberia (Irkutsk, *Schulz*); North China (Tinghai, *C. Ford*).

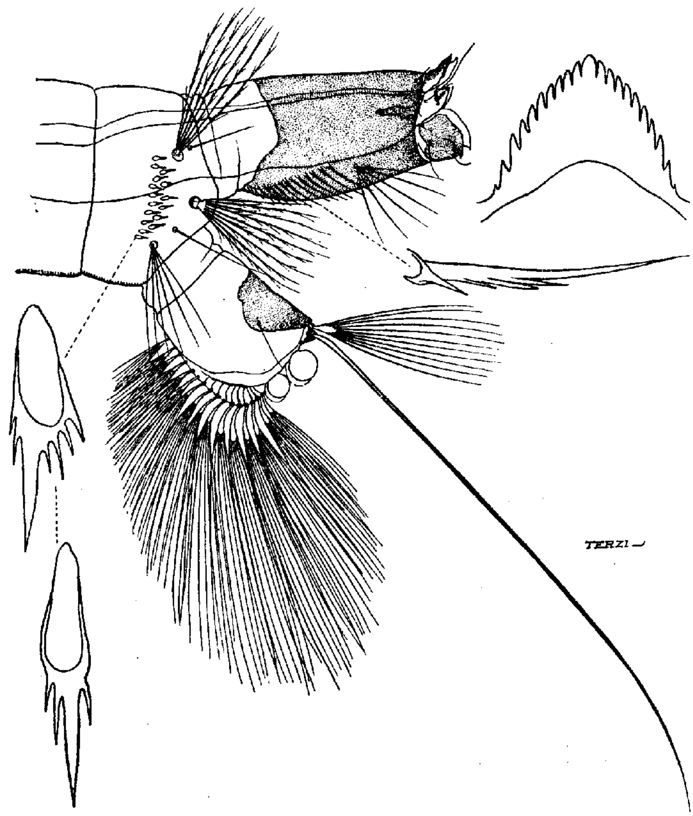


Fig. 9. *Aëdes mariae* (Serg.), end of abdomen of larva; comb and pecten teeth and mentum more highly magnified.

3. **Aëdes (Ochlerotatus) mariae** (Sergent) (figs. 6 b, 8 c, 9).

Culex mariae, Ed. & Et. Sergent, Ann. Inst. Pasteur, xvii, p. 62 (early in 1903).

Before having examined specimens of the true *A. pulchritarsis*, I took *A. mariae* to be synonymous with Rondani's species, but the two are in fact distinct. *O. mariae* has the wings, femora and tibiae, and even the tarsi in part, densely speckled with pale scales; the tarsal rings are creamy white and not very sharply marked; the mesonotal scales are almost uniformly ochreous without any bronzy tint. The male hypopygium resembles that of *O. caspius*, but the basal lobes of the side-pieces are smaller and carry no spines.

The Sergents' description of the larva being somewhat inadequate, fresh figures are given here, prepared from specimens collected by Capt. Barraud. These figures will explain themselves, but it may be specially noted that the antennae are almost devoid of small spicules, a very unusual character for this genus; the siphon is also remarkable in being almost as broad at the tip as at the base, the base being feebly or not at all chitinised (even in full-grown larvae); siphonal index 1·4–1·6. (It may be remarked here that Wesenberg-Lund's figure of the siphon of *A. caspius* is inaccurate; the tip in that species is really much narrower than the base.) The anal gills in *A. mariae* are minute and globular, as usual in salt-water breeders; the saddle is extremely small; formula of anal brush 10 + 4.

The species seems to be exclusively a salt-water breeder.

Distribution.—Algerian coast (*Sergent*); Southern France (*Séguy*); Palestine coast (Athlit, *Barraud*); Syria (Beirut, *Barraud*). Probably occurs also along the intervening Mediterranean coasts.

4. **Aëdes (Ochlerotatus) zammittii** (Theobald).

Acartomyia zammittii, Theobald, Mon. Cul. iii, p. 252 (25th July 1903).

This rather closely resembles *A. mariae*, the only difference I can detect in the adult being the presence of two more or less definite longitudinal stripes of white scales on the mesonotum, resembling those seen in *O. caspius*. The male hypopygia appear to be identical. The main reason for keeping the two distinct is the occurrence of certain larval differences. The two larvae of *A. zammittii* in the British Museum are both very much damaged, and one is immature, but the antenna has distinct spicules, and the pecten teeth are shorter, rather more numerous, closer together, and with more serrations than in *A. mariae*; it is possible they may have been wrongly associated with the adults, and in any case it is very desirable that more and better material should be obtained. If *A. zammittii* should prove identical with *A. mariae*, the latter name will stand for the species; it must have been published earlier, since Theobald quotes it (Mon. Cul. iii, p. 354).

Distribution.—Originally described by Theobald from Malta. I have also seen specimens with a more or less distinctly white-striped thorax from Palma, Majorca (*Grünberg*), and Southern France (*Dollfus, per Dr. Langeron*).

5. **Aëdes (Ochlerotatus) pulchritarsis** (Rondani).

Culex pulchritarsis, Rondani, Bull. Soc. Ent. Ital. iv, p. 31 (1872).
Culex leucacanthus, Loew, Beschr. Eur. Dipt. iii, p. 1 (1873).

In the specimens which I have examined there are no pale scales on the wings, the femora and tibiae are moderately speckled; the tarsi are black, with sharply marked white rings; the mesonotal scales rather variable, usually dull bronzy-ochreous with some patches of darker ones, sometimes, as in the specimens from Paris and Chitral, a more or less distinct central white stripe. It is just possible that the species may not be correctly identified, since Ficalbi in his detailed description says of the

wings, "con qualche brizzolatura chiaro." Ficalbi's description, however, fits this species much better than it does *O. mariae*. The two Italian specimens were both determined by Prof. M. Bezzi, who has seen Rondani's collection. Judging from the description, it seems highly probable that Loew's *C. leucacanthus* is the same species.

The larva is unknown. The male hypopygium differs from that of *A. mariae* and *A. zammittii* in having a single distinct spine on the basal lobe of the side-piece, the structure being otherwise similar.

Distribution.—Italy (Toscana, near sea, *Ficalbi*; Faenza, *E. Hargreaves*; Macerata, *Bezzi*); Macedonia (Bajirli, near Snevce, *Waterston*); Persia (Kasan, *Loew*); Paris (*Berland, Séguy*); Croatia (Novi, *Horváth*); Chitral (Drosh, *Walker*, 1915; *per Capt. P. J. Barraud*).

6. **Aëdes (Ochlerotatus) maculatus** (Meigen) (fig. 7 a).

Culex maculatus, Meigen, Klass. und Beschr. i, p. 4 (1804).
Culex cantans, Meigen, Syst. Beschr. i, p. 6 (1818).
Culicada waterhousei, Theobald, Ann. Mag. Nat. Hist. (7), xvi, p. 674 (1905).

This species may generally be distinguished from others of the group by its darker colour; the femora (especially the hind pair) have more numerous dark scales, the white rings on the tarsi are narrower, and the mesonotum is much darker, the pale scales occurring mainly on the posterior third and often forming a pair of spots just behind the middle and indistinct pale lines in front of the scutellum. There appear to be two more or less definite forms: a smaller, with entirely dark-scaled wings and distinct pale bands at the bases of the abdominal tergites, and a larger, with scattered pale scales on the wings and the abdominal bands more or less obsolete, the pale scales which are present occurring as much towards the apices as the bases of the segments. The peculiar male hypopygium, with its divided basal lobes and very broad appendage to the claspettes, is the same in both forms.

I am still unable to distinguish satisfactorily the larvae of *A. maculatus* and *A. annulipes*,* but the two species are certainly quite distinct. *A. maculatus* is essentially a woodland species, while *A. annulipes* (and most others of the group) prefer more open breeding-places.

This species has generally been known as *A. cantans*, though Meigen's description will apply as well or better to one of the other species of the group. For this reason Lang adopted the later name *waterhousei*. M. Séguy, however, informs me that males of this species are labelled *C. cantans* in Meigen's collection in Paris, and the identification of Theobald, de Meijere and others must therefore be regarded as correct. Meigen himself states that his *C. maculatus* was the male of *C. cantans*, and this statement must be accepted, since the type of *C. maculatus* no longer exists to prove or disprove it. Many of the earlier records of *C. cantans* apply no doubt to other species of the group.

Distribution.—Apparently confined to Europe, occurring chiefly north of the Alps. I have seen males from Britain; France (*Séguy, Langeron*); Belgium (*Goetghebuer*); Denmark (*Wesenberg-Lund*); Sweden (Stockholm, *Boheman*; Småland, *Haglund*); Finland (Kymmene, *Sallm.*); Germany (Urdingen and Frankfort-an-der-Oder, *Riedel*; Berlin, *Oldenberg, Lichtwardt*); Austria (Polzleinsdorf, *Schiner*; Moritzburg, *Kuntze*); Hungary (Munkács, *Ujhelyi*); also females, probably of this species, from Lappland (Qvikkjokk), and Italy (Turin, *Sangone*, *coll. Bezzi*).

* Séguy's figure of "*A. cantans*" in Bull. Mus. Paris, 1920, p. 327, really represents *A. communis*; his later figure of "*O. cantans*" in Bull. Soc. Ent. France, 1920, p. 310, probably represents *A. lutescens* (see Séguy, Bull. Soc. Ent. France, 1921, p. 165).

7. **Aëdes (Ochlerotatus) semicantans,** Martini (fig. 7 b).

Aëdes semicantans, Martini, Arch. f. Schiffs- und Tropenhyg. xxiv, Beiheft 1, p. 247 (1920) (diagnosis only), and Sitzb. u. Abh. natf. Ges. Rostock, vii, p. 205 (1920).

Resembles *A. maculatus* in coloration, being darker than the other four species of the group; the mesonotum has a more definite dark median stripe than in *A. maculatus,* and the abdominal segments have distinct basal white bands, which are narrowed in the middle, but the two are not easily separated, except by characters of the male hypopygium and larva, which are perfectly distinct. The hind femora are largely pale on the outer side, and the tarsal rings are broader than in *A. maculatus.* One or two North American species resemble this rather closely, but I have not at present been able to identify *A. semicantans* definitely with any North American form. The larva is very distinct on account of the small number of scales in the comb of the eighth segment.

Distribution.—Northern Europe; apparently widely distributed, but local. I have seen males from Sweden (Småland, *Boheman*); Germany (Hamburg, *Martini; Berlin, Stobbe;* Posen ?, *Loew*); Austria ? (*coll. Winthem*).

8. **Aëdes (Ochlerotatus) annulipes** (Meigen) (fig. 7 e).

Culex annulipes, Meigen, Syst. Beschr. vi, p. 241 (1830).

Aëdes quartus, Martini, Über Stechmücken, p. 128 (1920).

Meigen mentions the dark stripe in the middle of the mesonotum, the banded abdomen and pale femora, and I therefore have no doubt that the species is correctly identified. Zetterstedt, Ficalbi and others who have described the entirely yellow abdomen of the female probably had *A. lutescens* before them. In this species the abdomen almost always has distinct yellowish-white bands, which are situated mainly or entirely at the bases of the segments.

The larva is of the short-siphoned type, apparently identical with that of *A. maculatus* (except that the siphon is slightly shorter on the average), but very distinct from that of *A. excrucians.* It occurs typically in open swamps.

Distribution.—I have examined male specimens from England (various localities); Holland (Ghent, *Theobald*); Belgium (Wesembeek, *Tonnoir*); Germany (Urdingen, *Riedel;* Berlin, *Oldenberg*); Lower Austria (Speising, *Mik*); Hungary (Pressburg, *Mik;* Tultscha, *Mann*). A female from Sweden (Östergötland, *Haglund*) may be this species, but is perhaps more probably *A. excrucians.* Martini records it from the neighbourhood of Hamburg and Dantzig. It may be regarded as the western European representative of *A. excrucians,* though the ranges of the two species must overlap to some extent.

9. **Aëdes (Ochlerotatus) excrucians** (Walker) (fig. 7 f).

Culex excrucians, Walker, Ins. Saund. Dipt. p. 429 (1856).

Culex abfitchii, Felt, Bull. N.Y. State Mus. 79, p. 381 (1904); et auct.

(?) *Culicada surcoufi,* Theobald, Bull. Mus. Paris, xviii, p. 59 (1912).

Aëdes excrucians, Dyar, Insecutor Inscitiae, vii, p. 25 (1919), and viii, p. 109 (1920).

This species is most nearly allied to *A. annulipes,* but the abdomen is less distinctly banded, the dark bands being reduced to a more or less diamond-shaped spot on each segment; the dark colour is often more extensive in the female. The mesonotum usually has some obscure markings; rarely a distinct, broad, dark median stripe as in *A. annulipes.* The difference of structure in the male claspettes is slight but well defined. I can see no difference between American and European specimens, except that in the former the pale markings are cream-coloured rather than yellowish.

A. excrucians is evidently one of the commonest species of the group on the European continent (it has been described by Martini as *A. abfitchii*), and it is therefore

not surprising that it has frequently been determined either as *C. cantans* or as *C. annulipes*. I consider, however, that the evidence of the original descriptions and of the types in Meigen's collection in Paris is sufficient to allot these names to other species.

I learn from M. Séguy that the type male of *Culicada surcoufi* has been lost, so that there is now very little prospect of determining Theobald's species with certainty. A female which M. Séguy sent me for examination might have been either this species or *A. annulipes*. A female in Meigen's series of *C. cantans* in the Paris Museum is almost certainly *A. excrucians*.

Distribution.—I have examined male specimens from the following countries:—Finland (Hattula, *L. v. Essen;* Tvarminno, Messuby and Walkj, *R. Frey;* Eriksberg, *E. J. Bonsd.;* Karislojo, *J. Sahlberg*); Sweden (Södermanland, *Aurivillius;* Östergötland, *P. Wahlberg*); Denmark (*Wesenberg-Lund*); Germany (Berlin, *Lichtwardt, Oldenberg, Stobbe, Enderlein*); Austria (many in Winthem's old collection without definite data; one male labelled "rufibarbis, Gtl."); Hungary (Buda, *Biró;* Munkács, *Ujhelyi;* Berecsasz, *Kertész*); Saghalin Island (*Paul Labbé*, 1902). In addition I have seen many females which are probably this species, but cannot be determined with absolute certainty, including some from Siberia (Antsiferovo, 59° 10′, and Turuchansk, 65° 55′, *Trybom*). The species may therefore be assumed to have a continuous distribution over North Europe and North Asia; it is also known to be widely spread in North America. It appears to be absent from North-western Europe.

10. **Aëdes (Ochlerotatus) freyi,** sp. n. (figs. 7 d, 8 d).

Scales of head and mesonotum all small and yellow. Abdomen yellow, the tergites with black apical lateral patches, no median dark line. Male palpi longer than the proboscis by nearly the length of the last joint. Long joint with a yellow ring at the base and another beyond the middle; last two joints pale-scaled at the base; hairs long, brown. Proboscis all black. Tarsi with white rings at the bases of the joints; those on the middle joints of the hind tarsi slightly more than half of the length of the joints. Front and middle femora speckled in front, yellow behind; hind femora mostly yellow, with some black scales towards the tip. Wing-scales mostly dark, the costa yellow on about the basal third.

Hypopygium: side-pieces rather slender, fully three times as long as their greatest breadth. Basal lobe prominent, rounded apically, with a small patch of long hair, and a single long, weak, pale spine. Apical lobes rather large, somewhat pointed, with a few longish hairs. No arching-hairs on sternal side of side-piece. Claspette with long curved stem and broadly flattened appendage, the expansion commencing at the base. Lobes of ninth tergite each with about six short hairs.

This species, though resembling *A. lutescens* in coloration and *A. semicantans* in the structure of its hypopygium, is certainly distinct from both. The few examples I have seen are all more or less damaged and do not allow a very precise definition of the species on colour characters. Possibly the costa being yellow towards the base only instead of for the greater part of its length might distinguish the female of *A. freyi* from that of *A. lutescens*. The only undoubted female of *A. freyi* I have seen was considerably denuded; it had scattered light scales on the wings, and the proboscis largely pale except towards the base and tip.

Distribution.—Finland (Eriksberg, *E. J. Bonsd.*, type male in Helsingfors Museum); Germany (Berlin-Finkenkrug, 27.v.00, *L. Oldenberg*, 3♂, 1♀).

11. **Aëdes (Ochlerotatus) lutescens** (Fabricius) (fig. 7 c).

(?) *Culex flavescens*, Müller, Fauna Insectorum Friedrichsdalina, p. 87 (1764).
Culex lutescens, Fabricius, Syst. Ent. p. 800 (1775).
(?) *Culex variegatus*, Schrank, Enum. Ins. Austr. p. 482 (1781).

Culex flavescens, Fabricius, Syst. Antl. p. 35 (1805).
(?) *Culex bipunctatus*, Robineau-Desvoidy, Mém. Soc. d'Hist. Nat. Paris, iii p. 405 (1827).
Culex flavus, Motchulsky, Bull. Soc. Imp. Nat. Moscow, xxxii, pt. 2, p. 503 (1859).
Culex flavescens, Theobald, Mon. Cul. i, p. 410 (1901).
Culex arcanus, Blanchard, Les Moustiques, p. 303 (1904).
Culex fletcheri, Coquillett, U.S. Bur. Ent. Tech. Ser. 11, p. 20 (1906).
Aëdes cyprius, Ludlow, Insecutor Inscitiae, vii, p. 158 (1920).

Although this species seems to be subject to a good deal of variation, it may probably always be recognised by the predominantly yellow-scaled costa and the mainly or entirely yellow-scaled abdomen. In the lightest specimens the proboscis is yellow-scaled except at the tip, where the scales are black; the palpi and wings are almost entirely yellow-scaled; the mesonotal scales are rather light yellow; the thoracic integument is reddish, with a black patch in front from which three black lines extend backwards; the abdominal scales are all yellow in the female, usually with a median line of dark ones in the male; the tarsi, though with the usual white rings at the bases of the joints, have the dark portions largely replaced by yellow, except at the tips of the joints. In the darkest specimens the proboscis and palpi are almost entirely black-scaled, the wings are much darker, even the costa having a considerable sprinkling of dark scales; the mesonotal scales are rather deep brown, contrasting strongly with the white scales of the pleurae; the thoracic integument is nearly all black; the female abdomen has rather numerous dark scales at the sides; and the tarsi are darker. In some males the thoracic scales are almost white, and there are traces of a darker median band.

It is possible that the two forms above described may represent distinct varieties, or even species, but they appear to intergrade, and males associated with both dark and light females have practically identical hypopygia, the only difference observed being that some (though not all) of the light specimens had a more or less definite hook to the membrane of the claspette appendage (see fig. 7 c). Apart from this the hypopygium is well distinguished by the shape of the side-pieces, the very large basal lobes bearing a strong black spine, and the appendages of the claspettes, which have no membranous expansion on the basal third.

I at first considered that *A. lutescens* was identical with the American *A. fletcheri*, but there are some slight differences: in *A. fletcheri* the apical lobe of the side-piece of the male hypopygium is smaller, and the mesonotum has a distinct broad dark central stripe.

This, being a common European species, is much more likely to be Fabricius' *C. lutescens* than the rare one which Theobald has redescribed as such. Fabricius emphasises the yellow costa and the yellow proboscis with a black tip; he does not mention the tarsi, the statement that they are dark being due to Meigen, who may have had another species before him. Martini was of the same opinion regarding Fabricius' species, but did not adopt the name; I consider the identification sufficiently probable for the name to be used. Zetterstedt, Ficalbi and Martini use the name *annulipes*, Mg., for it, but this is certainly wrong, since the abdomen is never banded, as Meigen states is the case in *annulipes*. Although Motchulsky's diagnosis is very brief, I consider it highly probable that his *C. flavus* is our *A. lutescens*.

Distribution.—Europe, except the west; Siberia; extending in a slightly modified form into North America. I have seen specimens from Denmark (*Wesenberg-Lund*); Sweden (Östergötland, Scania, *Boheman*, light females); Finland (Kuustö, *Lundström*; Eriksberg, *E. J. Bonsd.*); Germany (Berlin, *Wanen, Lichtwardt, Oldenberg, Tetens*, females of light and dark forms; Radoj, *Loew*, dark female); Austria (Mödling, *Pokorny*; Michelstettin, *Bischoff*; Sterize, Styria, *Mann*; Weyshi, Steiermark, *Mann*; males, and females of dark form); Hungary (Pressburg,

Mik; Jaszenova, *Ujhelyi*; Kovákspatak, *Kertész*; Budapest, *Csiki*, males; Neusiedler See, *Mik*, and Munkacs, *Ujhelyi*, dark females); Ural (Winthem, light female); Siberia (Nasimovo, 59° 35', males and dark females; Nikulina, 60° 25', lighter male, *Trybom*; Omsk, *Granö*, light females); Kamtchatka (Bolsherjetsk, 20.vii.17, *Y. Wuorentaus*, light female); Asia Minor (Seraj-Koj, *Naday*, dark females).

12. **Aëdes (Ochlerotatus) rusticus** (Rossi).

Culex rusticus, Rossi, Fauna Etrusca, ii, p. 333 (1790).
? *Culex musicus*, Leach, Zool. Journ. ii, p. 293 (1825).
Culex pungens, Robineau-Desvoidy, Mem. Soc. Hist. Nat. Paris, iii, p. 407 (1827).
Culex quadratimaculatus, Macquart, Suites à Buffon, i, p. 34 (1834).
Culex diversus, Theobald, Mon. Cul. ii, p. 73 (1901).
Culex nemorosus var. *luteovittatus*, Theobald, Mon. Cul. ii, p. 85 (1901).

This is the largest species of the dark-footed group of the subgenus, and is very distinct from all the rest in the structure of the hypopygium and larva. The male has the palpi stouter than in most species; it can generally be distinguished even by the naked eye on account of the dense golden-yellow hairs which arch over the hypopygium, hiding the claspettes. The most strongly-marked form of the female, on which I have presumed Rossi's and Robineau-Desvoidy's original descriptions were based, shows a yellowish longitudinal stripe running the whole length of the abdomen, and dividing the black scales into two squarish areas on each segment; but it is commoner to find this longitudinal stripe distinguishable only on the last two or three segments, and such specimens will sometimes have to be examined carefully to avoid confusion with other species, such as *O. punctor* and *O. communis*. The pro-epimeral scales will separate it immediately from all other Palaearctic species.

An interesting variation is shown in a female from Szeged (*Kertész*), which has the abdomen almost entirely covered with yellowish scales, the black ones occurring only towards the middle of some of the segments without forming definite markings; the mesonotal scales are also much paler than usual, especially towards the sides. The pro-epimeral scales are normal for the species. A similar specimen from Budapest has been described by Theobald (Mon. Cul. iv, p. 344) as *Culex lutescens*, but, as stated above, I prefer to use Fabricius' name in another sense.

Walker (List Dipt. Brit. Mus. i, p. 8) queries *C. musicus* as the same as *C. quadratimaculatus*. The synonymy indicated may be correct, but the specimens are no longer in existence.

The larva is one of the few in this genus which lives through the winter, though perhaps many of the eggs do not hatch until the early spring. There is some individual variation in the number of hairs on the antero-dorsal side of the siphon.

Distribution.—West, central and south Europe. Locally common in England, France, Belgium, Germany and Denmark. Also Italy (*Rossi*; Taranto, *Hargreaves*; Livorno, *Mann*); Macedonia (*Waterston*). Not yet recorded from Sweden, Finland, Russia or Asia.

13. **Aëdes (Ochlerotatus) lepidonotus,** Edw. (figs. 5 b, 5 f, 8 e.)

Ochlerotatus lepidonotus, Edwards, Bull. Ent. Res. x, p. 132 (1920).

Distinguished by the characters given in the keys and by the uniformly pale-scaled abdomen of the female. The larva is unknown.

Distribution.—Macedonia (*Waterston*).

14. **Aëdes (Ochlerotatus) albescens,** sp. n.

Apparently related to *A. lepidonotus*, Edw., but the postnotum bears no scales. Almost all the scales of the body whitish, except on the proboscis and palpi, where they are mostly brown. Pro-epimeral scales whitish, rather narrow, some of them

curved. Palpi rather long, nearly one-third as long as the proboscis. Wings rather scantily scaled (not rubbed); veins all pale, membrane whitish; costal scales all whitish-yellow; first longitudinal vein with some dark scales. Integument of legs pale yellow, scales almost all whitish-yellow, those on the terminal tarsal segments browner; no sign of pale tarsal rings. Claws all toothed. Integument of thorax and abdomen blackish.

W. SIBERIA: Omsk (*Granö*); 1♀. Type in Helsingfors Museum.

15. **Aëdes (Ochlerotatus) alpinus** (Linn.).

Culex alpinus, Linnaeus, Flora Lapp. Ed. 2, p. 381 (1792).

Culex nigripes, Zetterstedt, Ins. Lapp. p. 807 (1838); Henriksen and Lundbeck, Med. Groenland, xxii, p. 595 (1917).

Aëdes innuitus, Dyar and Knab, Insecutor Inscitiae, v, p. 166 (1917).

Aëdes (*Ochlerotatus*) *nearcticus*, Dyar, Rept. Canad. Arctic Exp. iii, Pt. C, p. 32 (1919).

Aëdes alpinus, Dyar, Insecutor Inscitiae, viii, p. 52 (1920).

This species is fairly readily distinguishable by the unusually dense bristles on the thorax, looking, as Dyar has remarked, "as though it had a long woolly coat to keep out the cold." The very dark colour of the mesonotal scales, the black integument of the whole body, and the straight, shining greyish-white abdominal bands are also characteristic. However, since the density of the bristles is somewhat variable (smaller specimens being less bristly), and they are also rather liable to denudation (though less so than the scales), it is not always easy to distinguish the species from *A. cataphylla* and *A. parvulus*. In fact *A. alpinus* might almost be regarded as a race of *A. cataphylla* which has become adapted to arctic conditions by the multiplication of its bristles and the thickening of the chitin of the whole body.

I have failed to obtain a European male for examination from any correspondent, and it is very unfortunate that the good series of the species brought from north Russia by Capt. Carment and Dr. E. A. Cockayne consisted of females only. I am, however, indebted to Prof. Sjöstedt and Dr. Lundbeck for several males from south-west Greenland. These differ from the females (from the same place) in showing hardly any scales on the thorax; consequently they appear a good deal blacker; they are also even more hairy, especially on the abdomen. The hypopygium very much resembles that of *A. cataphylla*, except in being far more heavily chitinised, especially in the anal and genital parts. The apical lobe of the side-piece is very small, hardly distinguishable; the basal lobe has a moderately stout spine.

It seemed highly probable that these Greenland specimens were *A. innuitus*, D. & K., but that species was described as having a "double angular membrane" on the appendage of the claspette, as in *A. lazarensis*, while the males I have examined showed the normal single membrane. Dr. Dyar therefore re-examined the types of *A. innuitus*, and reports that the original description was in error; the membrane is really single, and the structure of the hypopygium of *A. innuitus* and *A. nearcticus* is really identical. That being so, there can be little doubt that *A. alpinus* is also the same, especially since we now know that a number of northern species of *Aëdes* are common to the Old and New Worlds.

Distribution.—Probably a circumpolar species, occurring in all the lands to the north of the Arctic Circle. I have seen males and females from south-west Greenland, and females from Finmark, Lappland, Murmansk, and north-west Siberia; also a female from the Paris Museum labelled "Fontainebleau, Dufour et Laboulbène." In regard to this last there must surely have been some mistake in labelling.

16. **Aëdes (Ochlerotatus) detritus** (Hal.) (fig. 7h).

Culex detritus, Haliday, Entom. Mag. i, p. 151 (1833).
Culex salinus, Ficalbi, Bull. Soc. Ent. Ital. xxviii, p. 29 (1896).
Culex terriei, Theobald, Mon. Cul. iii, p. 193 (1903).

This species is subject to a good deal of variation. Normally the dark parts of the abdomen are speckled over with light scales, but these are sometimes absent. Normally also the male palpi are entirely dark-scaled, but specimens are not infrequently met with in which the long joint bears a good many pale scales on its apical half. When both these variations occur together the specimens are not easy at first sight to distinguish from *A. salinellus*. Apart from the structure of the male hypopygium, which is of course diagnostic, the best distinctions are to be found in the almost uniform brown colour of the mesonotal scales of *A. detritus*, and the row of black spots down the middle of the venter, which are usually conspicuous in living specimens, though they are not so easily seen in the dry.

So far as known, the larva is confined to salt or brackish water, and, as in many other such forms, the gills are greatly reduced in size.

Distribution.—European coasts, from Ireland and France to Denmark and Macedonia; also coasts of North Africa, Suez Canal and Palestine. Apparently does not occur inland in eastern Europe, as do its frequent associates *A. caspius* and *A. dorsalis*. I have, however, seen a single male specimen, with a hypopygium identical with that of European *A. detritus*, from Kashgar, Chinese Turkestan (*Racquette*, in Stockholm Museum).

17. **Aëdes (Ochlerotatus) cataphylla,** Dyar, var. **rostochiensis,** Martini (fig. 7 l).

Aëdes cataphylla, Dyar, Insecutor Inscitiae, iv, p. 86 (1916).
Aëdes prodotes, Dyar, Insecutor Inscitiae, v, p. 118 (1917).
Aëdes rostochiensis, Martini, Über Stechmücken, p. 246, diagnosis only (1920), and Sitzb. u. Abh. natf. Ges. Rostock vii, p. 204 (1920).

This species and *A. salinellus* are together distinguished by the pale-speckled femora and the more or less conspicuous pale ring towards the end of the long joint of the male palpi; they differ from *A. detritus* in never having scattered pale scales on the dark parts of the abdomen, though the eighth segment is generally almost entirely pale. The two species *A. cataphylla* and *A. salinellus* are extremely alike; the most obvious difference in the adult is in the colour of the scales of the proboscis, which in *A. cataphylla* are almost all black, in *A. salinellus* extensively pale about the middle, but I am not sure how far this difference is constant. There is a slight but fairly well defined difference in the hypopygia (indicated in the key), but the most striking character of *A. cataphylla* is the presence of a couple of disconnected spines at the end of the pecten of the larval siphon.

None of the old European names seem to be applicable to this species, but I am satisfied that it is specifically identical with the western North American *A. prodotes*, Dyar (which Dyar now recognises to be the same as his previously described *A. cataphylla*). The male palpi have the same pale ring; the larva has the same two detached spines on the pecten, and the hypopygia are identical, except for a slight difference in the size of the apical lobes of the side-pieces. The American specimens, however, are on the average smaller, and the mesonotal scaling is rather different from the usual European type, being rather darker in the middle and with more numerous white scales at the sides. Nevertheless the Norwegian specimens in the British Museum have the sides of the mesonotum even whiter than the American specimens I have examined.

Distribution.—I have seen male specimens from Denmark (*Wesenberg-Lund*); Sweden (Småland, Stockholm and Dalecarlia, *Boheman*); Norway (Smaalenene,

Prof. O. Collet); Finland (Jämsa, *Bergroth*; Helsingfors; Hattula, *L. v. Essen*; Finnström, *Frey*; Sund, *Forsius*; Karislojo, *J. Sahlberg*; Kuusamo, *Frey*); Germany (Frankfurt-Oder, *Riedel*; Berlin, *Oldenberg*); Austria (Prater, *Mann*: this specimen was insufficiently examined and may have been *A. salinellus*); Siberia (Yeniseisk, 58° 20′, *Trybom*).

18. **Aëdes (Ochlerotatus) salinellus,** Edw. (fig. 7 k).

Aëdes salinellus, Edwards (?) in Wesenberg-Lund, K. Danske Vid. Selsk. Skr. Nat. Math. Afd. vii, p. 197 (1921).
Ochlerotatus salinellus, Edwards, Ent. Tidskr. p. 52 (1921).
Aëdes terriei, Martini (*nec* Theo.), Über Stechmücken, p. 112 (1920).

The distinguishing points of this species have been mentioned under *A. cataphylla*. In spite of their close similarity, there can be little doubt that the two species are distinct. I am not satisfied that any older name can be applied to this species. The type of *C. terriei* is certainly nothing but a normal, if rather small, female of *A. detritus*, which is common in the locality where *C. terriei* was taken. It is quite possible that *A. salinellus* may eventually be found to be the same as some known American species, but at present I have not been able to identify it with any such; it may be the European representative of *A. impiger* (=*decticus*, H.D.K.), which has the male palpi all black and fewer bristles on the ninth tergite.

The name *salinellus* was suggested partly because of the strong resemblance to *A. detritus* (*salinus*), and partly because the first specimens sent me by Dr. Wesenberg-Lund were reared from brackish water.

Distribution.—Northern and central Europe. I have seen males from England (Nottinghamshire, *Carr*); Denmark (*Wesenberg-Lund*); Germany (Berlin, *Oldenberg*, *Lichtwardt*; Kiel, *Wiedemann*); Austria (Vienna, *Pokorny*); Hungary (Budapest, *Kertész*; Bethlen, *Ujhelyi*; Pöstyén, *Lichtwardt*). Also some small females, probably of this species, from south Russia (Waloniki, *Velitschkovsky*). Martini records it from various places in north Germany, generally near the sea, sometimes in company with *A. detritus*.

19. **Aëdes (Ochlerotatus) diantaeus,** H.D.K.

Aëdes diantaeus, Howard, Dyar and Knab, Mosq. N. & C. Amer. iv, p. 758 (1917).
Aëdes serus, Martini, Über Stechmücken, p. 96 (1920).

An extremely distinct species in larva and male hypopygium; less well defined in the female, but recognisable by the deep bluish-black colour of the tibiae and tarsi, and the broad black stripe down the middle of the mesonotum. Owing to the colour of the legs, and the usually interrupted pale bands of the abdomen, the female might easily be mistaken for *A. geniculatus*, which of course differs in the structure of the tip of the abdomen, as well as in thoracic markings. I have compared adults and larvae of European and North American specimens, and can find no difference, except in the length of the anal gills of the larva, which is known to be a variable character. Neither of the published figures of the hypopygium is very accurate; in particular it should be noted that Martini's omits altogether the conspicuous hair-tuft of the side-piece.

Distribution.—I have examined the following European material:—Finland (Kuustö, Kuusamo and Küminki, *R. Frey*); Denmark (*Wesenberg-Lund*). Martini's material presumably came from the Hamburg district.

20. **Aëdes (Ochlerotatus) sticticus** (Meigen).

(?) *Culex lateralis*, Meigen, Syst. Beschr. i, p. 5 (1818).
Culex sticticus, Meigen, Syst. Beschr. vii, p. 1 (1838).

Culex concinnus, Stephens, Illustr. Brit. Ent. Suppl. p. 19 (1846).
Culex nigripes var. *sylvae*, Theobald, Mon. Cul. ii, p. 96 (1901).
Culicada sylvae, Theobald, Mon. Cul. iii, p. 194 (1903).
(?) *Aëdes aldrichi*, Dyar & Knab, Proc. U.S. Nat. Mus. xxxv, p. 57 (1908).
Culicada nigrina, Eckstein, Centralbl. f. Bakt. Abt. Orig. lxxxii, p. 67 (1918).
Culex nemorosus var. *dorsovittatus*, Villeneuve, Bull. Soc. Ent. France, p. 57 (1919).
Ochlerotatus dorsovittatus, Séguy, Bull. Mus. Paris xxvi, p. 408 (1920).
(?) *Ochlerotatus lesnei*, Séguy, Bull. Mus. Paris xxvi, p. 328 (1920).
Culicada nemorosa salina, Brolemann (*nec* Ficalbi), Ann. Soc. Ent. France, lxxxviii, p. 81 (1919).

This species is fairly easily recognisable by the general blackish colour, the white scales on the sides of the mesonotum, contrasting strongly with the dark brown stripe which occupies the middle third, and the whitish stripe on the outer side of the hind tibia of the female (often, though not always, present also in the male). The hypopygium (figured by Séguy and Brolemann) is characterised by the extremely short appendage to the claspette, which is very little longer than broad, and not much broader than the width of the stem, and by the large basal lobes, which are to a great extent separated from the side-pieces.

The species varies a good deal in size, though it is on the average smaller than *O. punctor*, to which it is most nearly allied. It also varies in regard to the abdominal bands of the female, which are in some specimens reduced to lateral spots (as in the type of *C. sticticus*, and as described by Eckstein for *C. nigrina*), while in others they are complete and scarcely even contracted in the middle (as in the types of *C. concinnus* and *C. sylvae*). I do not believe that these differences represent anything more than individual variation. Eckstein describes and gives rough figures of a difference between the hypopygia of his *C. nigrina* and what he regards as *C. lateralis*, stating that the appendage of the claspette is shorter and less broad in the latter than in the former. This may be true, and if so must indicate that we are dealing with two distinct species, but I have seen no specimens corresponding to Eckstein's figure of *C. lateralis*, and am inclined to think he has merely shown the same structure from two different points of view.

Since there may be two allied species here, and since there has been difference of opinion as to the interpretation of Meigen's *C. lateralis*, Theobald using the name for *A. geniculatus*, it does not seem advisable to adopt this earlier name for the species; the type of *C. lateralis* being no longer in existence, it seems best to follow Theobald in adopting Ficalbi's suggestion that it is the same as *C. albopunctatus*, Rond. (*A. geniculatus*). Of *C. sticticus* there is a female in good condition in Meigen's collection at Paris, and Séguy reports that the hind tibiae have a distinct pale stripe on the outer side. The name *sticticus* may therefore be used without further question.

I have examined the types of *C. concinnus* and *C. sylvae* and cotypes of *C. dorsovittatus*, and have no doubt as to their identity. Séguy's figure of the hypopygium of *O. lesnei* represents a structure apparently identical with that of *A. sticticus*, his other figure of *O. dorsovittatus* being rather inaccurate, besides showing the same structure in a different position. Specimens of *A. sticticus* were collected by M. Lesne in the same locality and at the same time as the type of *O. lesnei*, and I cannot help thinking that Séguy has confused two different species in his description: the tarsi of *O. lesnei* are said to have pale rings.

The North American species *A. hirsuteron* (Theo.), *A. aestivalis*, Dyar, and *A. aldrichi*, D. & K., are all very similar to *A. sticticus* in coloration, as well as in the male hypopygium, all having the same peculiar structure of the basal lobes. It is not at all unlikely that *A. sticticus* occurs in North America under one or other of these names. I can see no difference between European *A. sticticus* and American *A. aldrichi*, and consider that they are most probably identical, though distinctions

may be discovered on closer study, especially when the European form is better known.

According to Eckstein the larva of *A. nigrinus* lives in flooded meadows together with *A. vexans* and *A. dorsalis*, and several generations are passed through during the year. This does not accord with what is known of the habits of the allied North American species.

Distribution.—Widely spread in Europe, but seems to be nearly always rare. I have seen specimens (mostly females) from Scotland (Stephens' type ; also Aberfoyle, *Carter*) ; England (New Forest, Theobald's types) ; France (Melun, *Debreuil* ; Bois de Lutterbach, Bois de Borne, Chalampe, *P. Lesne*) ; Germany (Lüben, Rados, Halle, *Loew* ; Bonn, *Schneider* ; Berlin, *Lichtwardt*) ; Denmark (Jutland, *Wesenberg-Lund*) ; Austria (Linz, Kahlenberg, Aigen, *Mik* ; Dornbach, *Handlirsch* ; Prater, *Pokorny* ; Styria, *Mann*) ; Hungary (Szóváta, *Csiki*) ; Siberia (Asinovo, 61° 25' *Trybom*).

A long series collected by Dr. K. Kertész at Fuzine and Jasenak (Croatia) shows very little variation ; in all these the abdomen of both sexes has complete white basal segmental bands, and the dark-scaled area in the middle of the mesonotum is more extensive than usual, the specimens agreeing in this respect with many American examples of *A. aldrichi*, though not showing a pale median line dividing the dark area.

21. **Aëdes (Ochlerotatus) punctor** (Kirby) var. **meigenanus,** Dyar (fig. 7 g).

Culex punctor, Kirby, Fauna Boreali-Americana, Zool. Ins. p. 308 (1829).
Culicada (or *Ochlerotatus*) *nemorosus*, Theobald, de Meijere, Edwards, Lang (*nec* Meigen).
(?) *Culicada nemorosa* f. *haplolineata* and f. *alineata*, Schneider, Verh. Nat. Ver. Bonn, lxx, p. 37 (1913).
Aëdes punctor, Dyar, Insecutor Inscitiae, viii, p. 3 (1920), and ix, p. 71 (1921).
Aëdes meigenanus, Dyar, Insecutor Inscitiae, ix, p. 72 (1921).
Aëdes sylvae, Martini (*nec* Theobald), Über Stechmücken, p. 108 (1920).

This species is a variable one, and hence difficult to distinguish with certainty from its allies. The absence of a definite speckling of pale scales on the femora and tibiae, and the creamy tint of the abdominal bands—those on the last few segments being rather conspicuously narrowed in the middle—are, taken together, the best means of distinguishing the female. The male hypopygium is very distinct ; the large, prominent basal lobes and the short stem and strongly chitinised appendage of the claspette suggest that the species is really more nearly related to the *A. caspius* group than to the other members of the dark-legged group ; this supposition is to some extent borne out by the larval structure.

In the commonest type the mesonotum has brown or ochreous scales at the sides, with a broad longitudinal dark brown band in the middle ; this form is fairly distinct from other European species, though it might perhaps be confused with *A. sticticus* or *A. diantaeus* (*cf.* the distinctions of those species). Frequently, however, the dark central band of the mesonotum is either absent altogether or represented by two narrow bands, and such specimens are difficult to distinguish from *A. communis* or *A. pullatus*.

I have rejected the name *nemorosus* for this species, because there appear to be no examples of it so named in Meigen's collection in Paris, while there is a male of *A. communis* ; the name *nemorosus* has been used to cover so many species that there would be little advantage in retaining it. The present species is possibly Meigen's *C. sylvaticus*, but this is doubtful. While admitting that there are minute differences in larva and adult, as well as some distinction in breeding habits, between *A. punctor* and the European form, I cannot believe these are sufficient to justify

the maintenance of the two as distinct species. The European form should perhaps be known as *A. punctor* var. *meigenanus*. The hypopygium is identical in the two forms, and also in two or three other American forms which are regarded by Dyar as distinct species. The relationship of all these forms appears to require closer investigation.

It is quite possible that there may be more than one form in Europe, but the only evidence I have seen of this is provided by a male from Kuusamo, Finland, which has the hypopygium (and indeed the whole body) much more strongly chitinised than usual, and the hairs on the apical lobe rather longer. This may perhaps represent a distinct variety or species.

Distribution.—Apparently widely spread throughout northern Europe, and probably spreading across Siberia into Alaska and Canada. I have seen males from Britain; France; Belgium; Sweden (Stockholm, Småland, *Boheman*; Östergötland, *Wahlberg*); northern Lapland (*Boheman*); Finland (Kuusamo, Finnström, *Frey*; Kuustö, *Lundström*; Hattula, *L. v. Essen*; Karislojo, *J. Sahlberg*; Wiborg, *Pipping*; Jämsa, *Bergroth*; Tvarminno, *Levander*); Germany (Berlin, *Oldenberg*, *Stobbe*; Brocken, *Lichtwardt*); Hungary (Munkacs, *Ujhelyi*); also females, probably this species, from Austria (Hammern, *Mik*); Tyrol (Landro, *Mann*); Siberia (R. Ob, *Finsch*; Turuchansk, Yeniseisk, Inserovo, Antsiferovo and Nasimovo, all on R. Yenisei, *Trybom*).

22. **Aëdes (Ochlerotatus) parvulus,** sp. n. (fig. 8 f).

♂ Palpi all dark, long-haired, slightly shorter than the proboscis, proportions of joints, 55 : 26 : 19. Head-scales mixed in the middle, then grey, then a patch of blackish scales on each side; the broad lateral scales extend further up towards the middle of the head than usual; bristles black. Thorax dark brown; some white scales at the sides of the mesonotum; bristles rather dense. Abdomen black, the tergites with narrow straight basal bands of pure white scales. Legs almost all dark, the femora with only a few scattered pale scales and pale beneath. (Hind legs missing.) Length 4·5 mm.

Hypopygium: Lobes of ninth tergite each with about six short hairs. Basal lobe of side-piece prominent, rather pointed, with many long curved hairs but without a spine. Apical lobe very small, with a few short straight hairs. Claspette with the stem strongly curved; appendage with a broad membranous expansion commencing near the base.

♀ Similar to the male. Palpi about one-sixth as long as the proboscis. The hind tibiae have no pale lateral stripe. Length 3·5 mm.

A. parvulus has the appearance of a small, less hirsute race of *A. alpinus*, and perhaps it really is so, but the less strongly chitinised hypopygium, the absence of a spine on the basal lobes of the side-pieces, the slightly shorter male palpi, and the less speckled femora seem to be sufficient to distinguish it specifically.

Distribution.—Finland: Kittilä (♂ *F. Silén*, ♀ *U. Sahlberg*); type male and female in Helsingfors Museum; also several females, doubtfully conspecific, in Helsingfors and British Museums, from Karislojo (*J. Sahlberg*), Kusomen (*Hellén*) and Suomussalmi (*Hellén*); these last have mostly a fairly distinct pale hind tibial stripe, and the broad head-scales do not extend so far up as in the type.

23. **Aëdes (Ochlerotatus) communis** (De Geer) (fig. 7 j).

Culex communis, De Geer, Mémoires, vi, p. 316 (1776).
Culex nemorosus, Meigen, Syst. Beschr. i, p. 4 (1818).
(?) *Culex fasciatus*, Meigen, Klass. i, p. 4 (1804).
(?) *Culex leucomelas*, Meigen, Klass. i, p. 3 (1804).

(?) *Culex sylvaticus*, Meigen, Syst. Beschr. i, p. 6 (1818).
Aëdes obscurus, Meigen, Abbild. Zweifl. Ins. pl. ii, fig. 2 (1830).
Culex lazarensis, Felt & Young, Science, xx, p. 312 (1904).
Culicada nemorosa forma *diplolineata*, Schneider Verh. Nat. Ver. Bonn, lxx, p. 37 (1913).
(?) *Aëdes tahoensis*, Dyar, Insecutor Inscitiae, iv, p. 82 (1916).
(?) *Aëdes pionips*, Dyar, Insecutor Inscitiae, vii, p. 19 (1919).
Ochlerotatus palmeni, Edwards, Ent. Tidskr. p. 52 (1921).

This is one of a group of species which can only be satisfactorily distinguished by the structure of the male hypopygium. When this organ is mounted and examined under the high power of a binocular microscope, *A. communis* may be readily distinguished from other species by the two ridges at the base of the appendage of the claspette. These are best seen when the whole hypopygium is viewed from above; the small additional ridge is on the outer side of the appendage and at the base only. The long, strongly arched stem of the claspette and the form of the basal lobes seem to show that *A. communis* is more closely related to *A. cataphylla* and *A. salinellus* than to *A. pullatus* or *A. punctor*, though in coloration the first two species are more easily distinguished from *A. communis* on account of their speckled femora and tibiae. The indications of relationship afforded by the male hypopygium are also supported by the larval characters.

A. communis is evidently one of the most abundant woodland mosquitos of Europe, and is no doubt the species which has most frequently been identified as Meigen's *C. nemorosus*. This, together with the fact that a male of the species is included in Meigen's series of *C. nemorosus* in the Paris Museum, will definitely settle this name; although Meigen's description (brownish-yellow thorax, etc.) does not agree. De Geer's description of the adult and larva of *C. communis*, however, is quite sufficiently detailed for identification, and I have therefore adopted his name for the species. The disappearance of the name *nemorosus* from dipterological literature will be an advantage rather than otherwise, since it is now known that a number of species have been confused under this name.

I have examined the type of Meigen's *Aëdes obscurus*, which I received on loan through the kindness of M. Séguy. The hypopygium is apparently identical with that of *A. communis*, and the short palpi (if they were not merely broken) were therefore probably an individual abnormality similar to those which I have recorded as occurring in *A. punctor*.

In describing *C. nemorosus*, Meigen refers to his earlier description of *C. reptans* (Klass. i, p. 3, a doubtful identification of Linnaeus' *C. reptans*) as synonymous. In this earlier description, however, the tarsi are said to be white-ringed, so that the same species cannot have been referred to in both descriptions. The explanation probably is that Meigen intended to give a reference to his *C. leucomelas*, very briefly diagnosed immediately after *C. reptans*, with the remark, " Diese Art, die vielleicht nur eine Abändrung der vorigen ist, unterscheidet sich von derselben bloss durch die ganz schwarzen Füsse." This name *C. leucomelas* has been overlooked, and will unfortunately necessitate the renaming of a South American species.

Meigen's *C. sylvaticus* (*fasciatus*, 1804) is impossible to determine from the description, and I see no particular justification for Martini's suggestion that it is *Culex apicalis*; since the type does not exist it will be as well to accept Meigen's statement (Syst. Beschr. vi, p. 241) that it is only his *C. nemorosus*.

The American forms *A. lazarensis* and *A. tahoensis*, and probably also *A. pionips*, differ in such minute details that they can hardly be ranked as more than varieties of *A. communis*, but it is interesting to note that the hypopygium of the Alaskan *tahoensis* is the more nearly identical with European *communis* in regard to the exact position of the spine on the basal lobe of the side-piece, the only point in which Dyar has indicated distinctions between the American forms. I had intended to describe

a new species, *A. palmeni*, on account of some differences which I thought I perceived in the male hypopygium in two specimens from Finland. On a re-examination I failed to verify these differences, but meanwhile, unfortunately, I had published the name *palmeni* in my key to the Swedish species.

Distribution.—Europe, except west and south, and probably across Siberia to Alaska and Canada. I have examined male specimens from Denmark (*Wesenberg-Lund*); Sweden (Dalecarlia, Vesterbotten, Norrbotten, *Boheman*); Finland (Helsingfors, *J. Sahlberg;* Seitjaur, *Palmen*); France, Forêt de Marles, *Alluaud*); Germany (Berlin, *Lichtwardt*); Austria (Admont, Steiermark, *Strobl;* Richenau and Linz, *Mik;* Dornbach, *Handlirsch*).

I have also seen females, probably of this species, from Lappland and Siberia (Yeniseisk).

24. **Aëdes (Ochlerotatus) pullatus** (Coq.) var. **jugorum** (Villen.) (fig. 7 i).

Culex pullatus, Coquillett, Proc. Ent. Soc. Wash. vi, p. 168 (1904).
Culex jugorum, Villeneuve, Bull. Soc. Ent. France, p. 58 (1919); Séguy, Bull. Soc. Ent. France, p. 39, figs. (1921).
Aëdes metalepticus, Dyar, Insecutor Inscitiae, viii, p. 51 (1920).
Aëdes gallii, Martini, Über Stechmücken, p. 110 (1920).

This closely resembles *A. communis*, and it is almost impossible to distinguish the two satisfactorily, apart from the male hypopygium and the larva, which are very distinct. *A. pullatus* is somewhat smaller than *A. communis*, the integument is perhaps darker, and there are more numerous white scales on the mesonotum.

I have not seen the types, but an Italian male of *A. metalepticus* sent by Prof. Bezzi is practically identical in structure with an American male of *A. pullatus* in the British Museum; the distinctions given by Dyar must be due either to individual variation or to differences of mounting. The only differences observable in the Italian specimen were that the stem of the claspette was slightly stouter, slightly more angulated, and with a more distinct bristle arising from the angle; the main spine of the basal lobe was somewhat stouter, and the pale scales of the thorax whiter. These differences taken together may possibly indicate a varietal distinction.

Dyar suggested that *C. jugorum* might be the same as *A. metalepticus*, and this is almost certainly the case, but Séguy's figure of the hypopygium of a specimen (not the type) of *C. jugorum* shows a distinct apical hair-tuft on the side-piece, as in *A. intrudens*. The Verestorony examples that I have examined have an aggregation of hairs in this position, almost suggesting a tuft, and Séguy may have exaggerated the appearance of a tuft in his specimen, or the species may be somewhat variable. Both Séguy's and Kertész's specimens agree with Bezzi's except in this one point. As remarked by Villeneuve, there are long dense hairs arching over the upper (sternal) surface of the hypopygium, as in *A. rusticus*, *A. cataphylla*, and some others.

Distribution.—As yet imperfectly known; occurs in mountainous regions of Europe and North America, and therefore probably also of Central Asia. Recorded by Martini from Switzerland (*Galli-Valerio*), by Dyar from north Italy (*Bezzi*), and by Villeneuve from the Pyrenees (*Brolemann*). I have seen males from north Italy (Scais, *Bezzi*); Transylvania (Verestorony, *Kertész*); and the Balkans (Vermosa, 1200m., Greuze, *Penther*); also females, possibly of this species, from north Sweden (Kiruna, *Lichtwardt*).

25. **Aëdes (Ochlerotatus) intrudens,** Dyar (fig. 8 f).

Aëdes impiger, Howard, Dyar and Knab (*nec* Walker), Monogr. iv, p. 755 (1917).
Aëdes intrudens, Dyar, Insecutor Inscitiae, vii, p. 23 (1919).

I know of no satisfactory means of distinguishing the adults of this species from those of *A. pullatus* or *A. communis*, but the hypopygium is quite distinct, owing

to the dense tuft of hairs near the tip of the side-piece, projecting caudally from about the level of the apical lobe, though not actually from the lobe. The long hairs arching over the upper surface are not nearly so numerous as in *A. pullatus*. *A. diantaeus* also has a conspicuous hair-tuft, but in that species the tuft is situated about the middle of the side-piece and projects inwards. The claspette-stem in *A. intrudens* is angulated, with a projection arising from the angle, and a bristle on the projection.

Distribution.—Widely spread in Canada. I have seen only one European male, in the Berlin Museum, labelled 16.v.44, *H. Loew*. Dr. Enderlein informs me that Loew was most probably in the Posen district on this date.

Subgenus **Finlaya**, Theo.

Adult. Proboscis slender, longer than the front femora. Palpi short in the female; from one-half to nine-tenths as long as the proboscis in the male, the last two joints usually slightly thickened, moderately hairy and turned downwards. Head scales and ornamentation of thorax variable. Lower mesepimeral bristles absent. Male hypopygium with well developed claspettes, which bear a long and rather slender appendage; no apical or basal lobes to side-pieces; clasper and aedoeagus as in *Ochlerotatus*. Eighth segment of female only partly retractile, the sternite large and prominent in repose; cerci rather short. Front and middle claws of female toothed, the hind pair simple.

Larva. As in *Stegomyia*, with some exceptions.

Most if not all the members of this subgenus breed in tree-holes and similar situations or in rock pools. The species are most numerous in the Oriental region, but they are found in practically all parts of the world, except the polar regions. Owing no doubt to their restricted breeding-habits, there is a strong tendency in this subgenus to the production of local species, and comparatively few have a wide distribution.

Adults.

1. Tarsi (at least hind pair) with whitish rings 2
   Tarsi all dark 4
2. Tarsal rings extending on to apices of joints; thorax not distinctly lined *togoi* (Theo.).
   Tarsal rings at bases of joints only; thorax conspicuously lined 3
3. First three joints of hind tarsi ringed at base, last two all dark *japonicus* (Theo.).
   All joints of hind tarsi ringed at base .. .. .. *koreicus*, Edw.
4. Head scales almost all broad and flat; a large (sometimes divided) silvery-white area on the front of the mesonotum .. *niveus* (Ludlow).
   Head scales narrow except at the sides; mesonotum otherwise 5
5. Mesonotum with narrow lines of yellowish scales, sides not broadly whitish .. .. *eatoni* (Edw.).
   Sides of mesonotum broadly whitish scaled 6
6. Scales of scutellum mostly or all narrow and ochreous ..*geniculatus* (Oliv.).
   Scales of scutellum all broad, flat and white .. .. *echinus*, Edw.

Male Hypopygia.

1. Stem of claspette extremely short, knob-like.. .. .. *togoi* (Theo.).
   Stem of claspette about as long as the appendage 2
2. Side-piece with a tuft of large scales on the upper side .. *niveus* (Ludlow).
   Side-piece with small scales on the outer side only 3
3. Side-piece with very long and rather dense hair, as long as the side-piece itself, on the upper flap .. .. *eatoni* (Edw.).
   Hair on side-piece shorter, only about half as long as the side-piece .. 4

4. Lobes of ninth tergite with 6–8 fine hairs .. *japonicus* (Theo.); *koreicus*, Edw.
Lobes of ninth tergite with 2–4 stouter hairs .. *geniculatus* (Oliv.).

Since most of the larvae are unknown, a table cannot be given.

26. **Aëdes (Finlaya) togoi** (Theobald).

Culicelsa togoi, Theobald, Mon. Cul. iv, p. 379 (1907).

This is very distinct from the other Palaearctic species of the subgenus, both in the tarsal markings and in the male hypopygium, which shows the following characters :—Side-pieces a little over twice as long as their depth at the base; upper flap much expanded basally, its inner margin with a dense row of long, slightly flattened bristles or bristle-like scales, extending the whole length except on the expanded basal portion; the lower flap has an aggregation of hairs at the base, but no definite basal lobe. Claspers moderately long, nearly cylindrical, tapering; terminal spine not very long. Claspettes with the stem extraordinarily short, reduced to a mere knob; appendage sickle-shaped, slender, not expanded in the middle. Lobes of ninth tergite small, with about 6–8 moderately long hairs.

The male palpi are about three-quarters as long as the proboscis, nearly straight and slightly hairy.

The larva is undescribed (unless recently by Yamada); Dr. Lamborn found them in granite basins in cemeteries.

Distribution.—Japan (Osaka, *Theobald;* Tokio, *S. Yamada, Harmand;* Yokohama and Kobe, *Lamborn*); eastern Siberia (Vladivostok, *per Dr. C. S. Ludlow*).

27. **Aëdes (Finlaya) japonicus** (Theobald).

Culex japonicus, Theobald, Mon. Cul. i, p. 385 (1901).

Apart from the tarsal characters, which are diagnostic, this species is noteworthy for the fine yellowish lines on the mesonotum; similar lines are found in *A. koreicus* and *A. eatoni*. The male palpi are slightly shorter than the proboscis, slender, the last two joints somewhat upturned, and with rather scanty hairs, thus approaching very nearly to the type of palpi found in *Stegomyia*. The male hypopygium is extremely similar to that of *A. geniculatus*. Theobald suggested that this might possibly be the same as *A. aureostriatus* (Dol.), but this is unlikely.

The larva is undescribed, unless recently by Yamada; Dr. Lamborn found a few in similar situations to those in which he took *A. togoi.*

Distribution.—Japan (Tokio, *Theobald, Yamada;* Kofou, *L. Drouard de Lezey;* Chuzenji, *E. Gallois;* Nagasaki, *Lamborn*).

28. **Aëdes (Finlaya) koreicus,** Edw.

Ochlerotatus (Finlaya) koreicus, Edwards, Bull. Ent. Res. vii, p. 212 (1917).

This should probably be ranked as a variety of *A. japonicus*, from which it differs in little else than in having narrow white rings at the bases of the last two hind tarsal joints. The palpi of the type male are perhaps slightly less hairy than in *A. japonicus*.

The larva is unknown.

Distribution.—Korea (*Dr. R. G. Mills*).

29. **Aëdes (Finlaya) niveus** (Ludlow).

Stegomyia nivea, Ludlow in Theobald, Mon. Cul. iii, p. 139 (1903).
Stegomyia pseudonivea, Theobald, Ann. Mus. Nat. Hung. iii, p. 75 (1905).
Stegomyia albolateralis, Theobald, Rec. Ind. Mus. ii, p. 289 (1908).

In typical examples of *A. niveus* the silvery area on the scutum forms a solid patch, but in some specimens (generally females) it is divided more or less completely by a dark median stripe, which may even reach the front margin. The

specimens with this dark stripe (such as the Japanese examples recorded below) may represent a distinct species or variety (*albolateralis*, Theo.), but in view of Leicester's remarks on the variability of the species I doubt if this is so. Unfortunately, I did not examine the hypopygium of the Japanese male. A male from the Andaman Islands shows the following characters :—Side-pieces about twice as long as their depth (or three times as long as their width) at the base, tapering, densely scaly on their outer and under sides, finely hairy on the inner side, some long hairs at the base beneath ; a dense row or tuft of very long and broad scales on the upper (sternal) side, not reaching the base. Claspers short, with a very long terminal spine which is quite two-thirds as long as the clasper itself. Lobes of ninth tergite with about four very long bristles. Claspettes with the appendage moderately expanded in the middle, about equalling the stem in length. The male palpi are of practically the same length as the proboscis, the last two joints turned downwards and bearing long hairs.

If Eichwald's *Culex niveus* is an *Aëdes*, the name is ineligible for this species, and *pseudoniveus* should be used instead, but in view of the uncertainty there is perhaps no necessity to make the change.

The larvae are not yet described, though Leicester records finding them in cut bamboos.

Distribution.—A widely-spread Oriental species extending into Japan (Tokio, *S. Yamada*; 1 ♂ 1 ♀ in coll. *M. Koidzumi*).

30. **Aëdes (Finlaya) eatoni** (Edw.).

Ochlerotatus eatoni, Edwards, Bull. Ent. Res. vi, p. 358 (1916).

Apart from the very different thoracic markings, this species differs from *A. geniculatus* in the coloration of the hind femora, which are black above for their whole length, instead of entirely white on the basal half. The female and larva remain unknown, the description being based on a single male, the palpi of which are only about two-thirds as long as the proboscis.

Distribution.—Madeira Island (*Eaton*).

31. **Aëdes (Finlaya) geniculatus** (Oliv.) (figs. 1 b, 5 g, 10 a).

Culex geniculatus, Olivier, Encycl. Méth. Hist. Nat. Ins. vi, p. 134 (1791).
(?) *Culex lateralis*, Meigen, Syst. Beschr. i, p. 5 (1818) et auct.
Culex ornatus, Meigen, Syst. Beschr. 1, p. 5 (1818).
Culex guttatus, Curtis, Brit. Ent. p. 537 (1834).
Culex fusculus, Zetterstedt, Dipt. Scand. ix, p. 3459 (1850).
Culex albopunctatus, Rondani, Bull. Soc. Ent. Ital. iv, p. 31 (1872).

The shining white, almost silvery knee-spots, and the coloration of the hind femora will distinguish even somewhat rubbed adults of this species from any member of the subgenus *Ochlerotatus*. Fresh specimens are obviously distinct by their thoracic markings. From the allied *A. echinus* this species differs mainly in the narrower scutellar scales ; but even this is not absolutely diagnostic, as I have seen a male from the south of France which is certainly only *A. geniculatus*, but which has some small flat scales on the scutellum. The larva, however, is very different from that of *A. echinus*, and as it is the only other species of the genus which is found in tree-holes in Europe, no confusion with any other species is likely.

As I have previously stated (Ent. Mo. Mag. 1912, p. 277), I do not think there can be any doubt that Olivier's name should apply to this species, and that Theobald was in error in using it for *Culex hortensis*. I now believe that the female which Meigen originally described as *C. ornatus* must have been this species, although the male which he described at a later date must have been something else, as he refers to the white marks on the palpi. Van der Wulp, Verrall, Galli-Valerio

and others who identified *C. ornatus* as this species were therefore probably right. Meigen's *C. lateralis* may also be the same, as supposed by Theobald, but the type being lost it is impossible now to say whether it was this species or *A. sticticus*. Mr. J. E. Collin has kindly examined for me the two males of *C. fusculus* in Zetterstedt's collection at Lund, and from his notes and accompanying sketch of the claspette there can be no doubt that *C. fusculus* is *A. geniculatus*. Zetterstedt must also have included with these males rubbed females of other species, as one which was sent me by Dr. Bengtsson in 1912 was an *Ochlerotatus* near *O. cataphylla*.

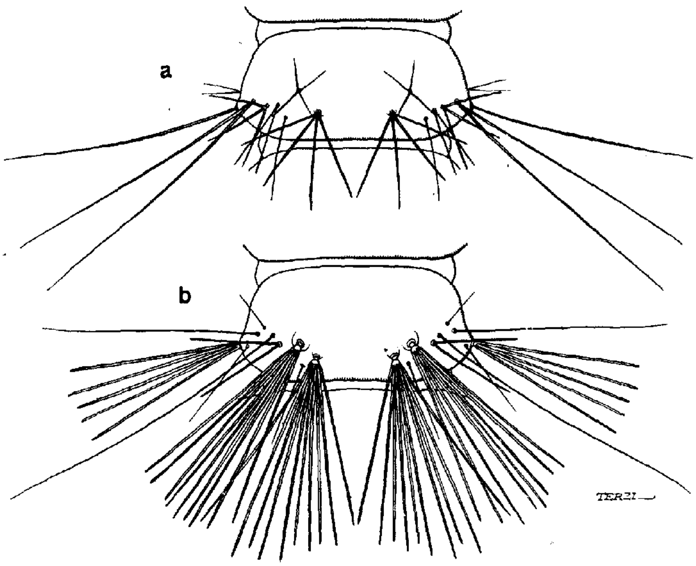


Fig. 10. First abdominal segment of larva of (a) *Aëdes geniculatus* and (b) *Aëdes echinus*, showing the remarkable difference in the development of the hairs.

Distribution.—Throughout Europe from France to Galicia and from south Sweden to Macedonia, wherever there are deciduous trees, such as beech, sycamore, plane, horse-chestnut, sweet chestnut, etc., in sufficient numbers. It occurs also in Corsica (*Yerbury, Séguy*) and in Asia Minor (Brussa, *Mann*). It is not yet known from Siberia or North Africa, though its known range will no doubt be extended by future observations. The most northerly record I have is Scania, Sweden (*Boheman*). Its absence from the far north may be accounted for by the fact that coniferous trees, also birches and willows, do not readily form rot-holes that will contain water. Its apparent absence from Scotland and Ireland is not so easy to explain. The North American representative (*A. triseriatus*, Say) is specifically distinct.

32. **Aëdes (Finlaya) echinus** (Edw.) (figs. 6 a, 10 b, 11).

Ochlerotatus (*Finlaya*) *echinus*, Edwards, Bull. Ent. Res. x, p 133 (1920).

The adult is very similar to *A. geniculatus*, apart from the two points mentioned in the key, but the larva is strikingly different, chiefly on account of the remarkable development of the hair-tufts on the thorax and abdomen. These appear to correspond rather closely in number and position with those of *A. geniculatus*, but the component hairs are more numerous, distinctly plumose, somewhat longer, and much stouter, giving the insect a very urchin-like appearance (whence the specific

name). Fig. 10 illustrates well the difference in vestiture of the first abdominal segment in the two species; the following segments in both have the hairs longer. (In the case of *A. echinus* both the skins preserved by Capt. Waterston are much distorted, and careful reconstruction was necessary.) The larva of *A. echinus* also differs from that of *A. geniculatus* in the distinctly longer antennae, which are much more extensively pale towards the tip, in the much more numerous pecten teeth, which are in a straighter row, in the somewhat smaller siphon and somewhat larger comb teeth, as well as in some other details, perhaps not constant.

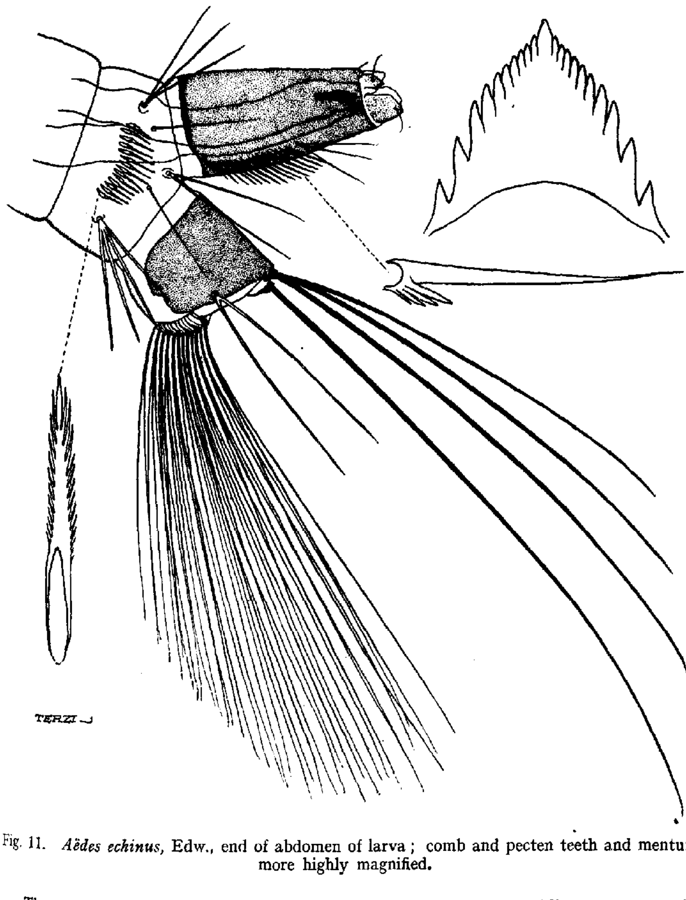


Fig. 11. *Aëdes echinus*, Edw., end of abdomen of larva; comb and pecten teeth and mentum more highly magnified.

The pupa differs from that of *A. geniculatus* in having the paddles more strongly emarginate and the terminal hair placed at some distance outside the tip of the midrib.

Distribution.—Macedonia (Stavros, *Waterston*; reared from larvae in hole in plane tree; many adults of *A. geniculatus* also found in the same locality); Morocco (Fez, *Fowler*); Algeria (*Sergent*).

Subgenus **Ecculex,** Felt.

Adult.—As in *Ochlerotatus,* but the male palpi are usually no longer than the proboscis; the vertex and the scutellum in many species are covered with flat scales; lower mesepimeral hairs are usually absent; the male hypopygium has no distinct claspettes, these being represented by hairy basal lobes; while, on the other hand, the claspers are highly modified in most species, and even in the simple forms are distinguished by having the spine inserted before the tip. The aedoeagus is quite different from that of *Ochlerotatus,* but almost identical with that of *Aëdes.* The hind claws are usually simple.

Larva.—Practically as in *Ochlerotatus,* but the pecten usually has detached teeth outwardly, which in *Ochlerotatus* is rarely the case, and the siphonal tuft is usually distinctly beyond the middle.

In *E. vexans* the frontal hairs are situated one in front of the other, as in *Ochlerotatus,* but in the rather numerous Ethiopian species of which the larvae are known the anterior pair is placed outside the posterior, as in *Culex* and *Aëdes* (*s. str.*).

It is only with reluctance, in deference to the opinion of Dyar, that I recognise this as a distinct subgenus, as it is almost impossible to define apart from the characters of the male hypopygium. However, there is no doubt that it is a natural group, representing a distinct line of evolution in which the clasper has undergone specialisation instead of the claspette. The separation is confirmed by present-day distribution, the species being numerous in the Oriental and Ethiopian regions, only a single one extending into the Palaearctic and Nearctic, while none are found in the Neotropical, and only one or two in north Australia.

33. **Aëdes (Ecculex) vexans** (Mg.).

Culex vexans, Meigen, Syst. Beschr. vi, p. 241 (1830).
(?) *Culex parvus,* Macquart, Suites à Buffon, i, p. 36 (1834).
Culex articulatus, Rondani, Bull. Soc. Ent. Ital. iv, p. 30 (1872).
Culex malariae, Grassi, Atti Acc. Lincei, vii, p. 168 (1898); Noé, Bull. Soc. Ent. Ital. xxxi, p. 244 (1899).
(?) *Culex arabiensis,* Patton (adult, not larva), J. Bombay Nat. Hist. Soc. xvi, p. 633 (1905).

Apart from the characters of the male hypopygium and the somewhat shorter male palpi, this species is not easy to distinguish from the *annulipes* group of the subgenus *Ochlerotatus,* especially small specimens of *A. maculatus.* The structural and scale characters are the same, except that the hind claws are often (not always) simple; in both the lower mesepimeral bristles are absent. We have therefore, in the case of the female, to rely mainly on coloration for the determination of this species, the most constant feature being the median emargination of the pale abdominal bands. The white tarsal rings are always narrow, but rather variable; in large specimens they are sometimes not much narrower than those of the narrowest-banded specimens of *A. maculatus;* while in the other examples (generally small ones) they are often so narrow as to be visible only under a lens. The head markings (the uppermost of the flat scales at the sides of the head being black, the rest pale) are of a type very rarely met with in *Ochlerotatus,* but common in *Ecculex, Stegomyia* and *Finlaya.* *E. vexans* differs from the great majority of species of the subgenus in having no flat scales either on the vertex or on the scutellum, its resemblance to the subgenus *Ochlerotatus* being thus increased.

Two varieties occur within the Palaearctic region: the typical form, in which the abdomen has only the emarginate white bands on a dark ground; and the variety *nipponii,* Theobald, in which the abdominal segments have, in addition to the bands, a median whitish patch.

The species is so abundant in many parts of Europe as to constitute a serious plague; so much so that, according to Eckstein and others, agricultural work in some districts has to be carried on by night and cattle stalled during the day, owing to the attacks which *A. vexans* makes by day on the men and cattle.

The larva occurs characteristically in flooded meadows, and several generations are passed through in the year. There is very little difference between the larva and those of some species of *Ochlerotatus* which have detached teeth at the end of the pecten, even the distinctions given in the key being somewhat doubtful. According to the figure and description in Howard, Dyar and Knab's monograph (where the species is named *A. sylvestris*, Theo.), the siphonal tuft is situated in the middle, though according to Schneider and Martini it is placed well beyond the middle. The only larvae I have seen are from Ceylon, and these agree entirely with Martini's description; I suspect therefore that the American description may be in error, as there is certainly no difference in the adults.

Distribution.—Apart from the domestic species (*Culex pipiens*, *C. fatigans* and *Aëdes argenteus*), this is the most widely spread ot all mosquitos, occurring practically throughout the Palaearctic, Oriental and Nearctic regions. Possibly it may have had its origin in tropical Africa, where there are a number of related forms, but if so its apparent absence from that region at the present time is remarkable. It is common throughout central Europe, perhaps less so in the south, and certainly rare in the north. Some fresh records are: Sweden (Oeland I., *Boheman*); Finland (Helsingfors, *Frey*; Tvarminno, *Levander*); Italy (Susa, Sondrio, Torino, Macerata, Chivasso, *Bezzi*); Asia Minor (Konia, *Naday*); Transcaspia (Tashkent, Aschabad, *C. Ahnger*); Ussuri (Spasskaja, *Wuorentaus*); Persia (Enzeli, *Buxton*); Korea (*Yamada*); Aden (*Kazan Chand, per Capt. P. J. Barraud*).

The variety *nipponii* occurs in China and Japan, also the Amur region (Ussuri, Spasskaja, *Wuorentaus*).

Subgenus **Aëdes**, Mg.

Adult. Proboscis (in the Palaearctic species) about equal in length to the front femora, or slightly shorter. Palpi very short in both sexes. Antennae of the male with the hair-whorls evenly spread all round the joints. Vertex with broad flat scales, leaving only a small patch of narrow ones on the nape. Lower mesepimeral bristles absent. Male hypopygium with the claspers deeply bifid, without terminal claw, inserted before the tip of the side-piece; the latter with small hairy basal lobes. Aedoeagus with the parameres indistinct, almost membranous, the mesosome chitinised in two lateral halves, which are split into rather numerous small spines; one very much larger spine is apically directed. Female cerci moderately elongate; eighth segment rather large. Front and middle claws of female toothed.

Larva. Antennae rather long, with numerous spinules and well-developed tuft. Frontal hairs not one in front of the other, as in *Ochlerotatus*, but almost side by side (in Lang's terminology, the three post-antennal hairs are almost in one line, the middle one not displaced). The median anterior thoracic tufts are absent.

34. **Aëdes (Aëdes) cinereus,** Mg.

Aëdes cinereus, Meigen, Syst. Beschr. i, p. 13 (1818).
Aëdes rufus, Gimmerthal, Bull. Soc. Imp. Nat. Moscou, xviii, p. 295 (1845).
Aëdes leucopygus, Eysell, Abh. Ver. Naturk. Kassel, xlviii, p. 285 (1903).
Culex nigritulus, Zetterstedt, Dipt. Scand. ix, p. 3459 (1850).
Aëdes fuscus, Osten-Sacken, Bull. U.S. Geol. Surv. iii, p. 191 (1877).
? *Culex ciliaris*, Linnaeus, Syst. Nat. Ed. xii, i, p. 1002 (1767).

This species need not be confused with any other in the Palaearctic fauna. The mostly flat-scaled head, extremely short palpi of the male, reddish, unmarked thorax,

and dark-scaled dorsum of the abdomen of the female, should make it quite unmistakeable. So far as European specimens are concerned there is little variation, though it should be noted that the thorax of the male is always much darker than that of the female, usually quite black.

The larva does not differ in any very striking manner from those of the subgenera *Ochlerotatus* and *Ecculex*; the main points have already been noted. The early stages are spent usually in flooded meadows and large marshes, but the species is also found in woods. It is commonly associated with *A. vexans*.

Distribution.—Throughout Europe, and extending across Siberia to North America, where it has a wide distribution. The following are some new records:—Italy (Sondrio, *Bezzi*); Finland (various localities and collectors); Siberia (Yeniseisk, 58° 20′, and Turuchansk, 65° 55′, *Trybom*; Omsk, *Granö*).

Subgenus **Stegomyia**, Theo.

Adult. Proboscis moderately slender, but stouter than in *Ochlerotatus*, scarcely as long as the rather short front femora. Palpi short in the female, normally longer than the proboscis in the male, the last two joints slender, upturned, with very few hairs. Vertex with broad flat scales, few or no narrow ones on the nape. Thorax usually with conspicuous and well-defined ornamentation. Lower mesepimeral bristles absent. Male hypopygium usually without claspettes, unless these are represented by hairy basal lobes; no apical lobes; clasper with distinct terminal spine. Aedoeagus divided into two more or less brush-like halves. Eighth segment of female abdomen rather large, but distinctly retractile, the sternite not very prominent in repose; cerci rather short. Front and middle claws of the female either toothed or not.

Larva. Antennae short, with single hair and without spicules on shaft. Frontal hairs single. Abdomen with or without numerous stellate tufts on dorsal surface; the eighth segment with a definite comb of teeth set in a single row. Siphon not much more than twice as long as broad; hair-tuft well developed and situated about the middle.

The larvae of many African species live in tree-holes, leaf-axils, etc., and these species show a much greater development of the abdominal hair-tufts than is seen in the Palaearctic species.

Adults.

1. Mesonotum with a median silvery-white line 2
   Mesonotum without such line 3
2. Female claws simple (Japan) .. .. *albopictus* (Skuse).
   Female claws toothed (Crete) .. .. *cretinus*, sp. n.
3. Mesonotum with a lyre-shaped silvery-white mark; tibiae dark except at tip .. .. *argenteus* (Poiret).
   Mesonotum with four distinct white dots; tibiae ringed with white a little beyond the middle .. .. *vittatus* (Bigot).

Male Hypopygia.

1. Clasper modified, swollen and hairy apically, the spine long and curved and placed far before the tip .. .. *vittatus* (Bigot).
   Clasper normal; spine shorter, straight, and terminal 2
2. Clasper shorter, narrowed at the tip, side-piece with a large, densely bristly area .. .. *argenteus* (Poiret).
   Clasper longer, slightly swollen at the tip, side-piece with a large, hairy basal lobe .. .. *albopictus* (Skuse).

35. **Aëdes (Stegomyia) albopictus** (Skuse).

Culex albopictus, Skuse, Ind. Mus. Notes iii, p. 20 (1895).
Stegomyia scutellaris, Theobald (*nec* Walker), Mon. Cul. i, p. 298 (1901).

This is the only species of *Aëdes* in the Palaearctic region in which the front and middle claws of the female are not toothed; it cannot however be removed from the genus, or even from the subgenus *Stegomyia*, with which it agrees in all other respects. The silvery line down the middle of the mesonotum will at once differentiate it from all other mosquitos in the region except *A. cretinus*, its Mediterranean representative.

The larva has been described and figured by Banks (Phil. J. Sci. A, iii, 1908, p. 246) but he omits to notice the structural difference from *A. argenteus* in the shape of the comb-teeth.

Distribution.—A common semi-domestic species throughout the Oriental region, occurring in Japan in the neighbourhood of Tokio (*Yamada*); Mt. Takao, near Hachioji and Kofou (Paris Museum); Yokohama and Kobe, also Shanghai (*Lamborn*). It occurs also in Madagascar and Réunion.

36. **Aëdes (Stegomyia) cretinus,** sp. n.

Closely allied to *A. albopictus*, Skuse, but differs as follows:—A pair of small round spots of white scales in the middle of the mesonotum, a little in front of the wing-roots level with the posterior end of the central white stripe. Abdomen with very distinct white basal bands on segments 2–7, somewhat narrowed in the middle. Fourth hind tarsal joint darkened only at the extreme tip. Front and middle claws toothed. As in *A. albopictus*, the front and middle femora have a narrow line of white scales towards the base anteriorly, but no median white spot.

A single female in Herr Lichtwardt's collection, labelled "Creta. v. O. *Culex calopus*, Mg." Since, apart from the toothed claws, there are slight differences from both *A. albopictus*, Skuse, of the Oriental region, and *A. unilineatus*, Theo., of Africa and the Punjab, it is more likely that we are dealing with a distinct Mediterranean representative of *A. albopictus* than that there has been any error in labelling.

A second female is in the Buda-Pest Museum from Amari, Crete, 4. vi. 1906 (Biró); the abdomen and claws agree with the type, but the mesonotum is rubbed and the hind tarsi missing.

37. **Aëdes (Stegomyia) argenteus** (Poiret) (*Stegomyia fasciata*).

Culex argenteus, Poiret, Journ. de Phys. xxx, p. 245 (1787).
Culex fasciatus, Fabricius, Syst. Antl. p. 36 (1805).
Culex calopus, Meigen, Syst. Beschr. i, p. 3 (1818).
Culex konoupi, Brullé, Exp. Sci. de Morée, Zool. iii, p. 289 (1836).
(?) *Culex niveus*, Eichwald, Reise Casp. Kauk. ii, p. 183 (1837).
Culex elegans, Ficalbi, Bull. Soc. Ent. Ital. xxi, p. 95 (1889).
Culex albopalposus, Becker, Mitt. Zool. Mus. Berlin, iv, p. 80 (1908).
Culex angustealatus, Becker, Mitt. Zool. Mus. Berlin, iv, p. 79 (1908).
? *Culex aegypti*, Linnaeus, Hasselquist's Reise nach Palestina, p. 470 (1762).

The yellow fever mosquito is widely spread, though apparently nowhere very abundant, in the warmer parts of the Palaearctic region. It occurs on the Atlantic islands, in Portugal, and all round the Mediterranean coasts. In the eastern Mediterranean it is by no means confined to the coasts, since Barraud has found it to be common at Aleppo. Further east it is known from Mesopotamia, Persia, and Japan.

Eichwald says of *Culex niveus*, which he records from Tiflis and Baku, "in unzähliger Menge abends in den Zimmern bemerkt werden." This, together with his "thorax nigro alboque varius, alba pube obsitus" and "pedibus nigro canoque variis," seems to suggest *Aëdes argenteus*, but other parts of the description (" alis

niveo-albis, corpore ex dimidio fere brevioribus," and "pedibus anticis in apice utrinque fasciculo pilorum ornatis") will not apply to this or any other known mosquito.

It is quite possible that Dyar may be right in identifying *C. aegypti* with this species. Certainly it seems to be some *Stegomyia*, and *A. argenteus* is the only member of the genus now known to occur in Egypt, but there are one or two points in the description which quite definitely do not agree; I have therefore not adopted the name.

38. **Aëdes (Stegomyia) vittatus** (Bigot).

Culex vittatus, Bigot, Ann. Soc. Ent. France, (4) i, p. 327 (1861).
Stegomyia sugens, Theobald, Mon. Cul. i, p. 300 (1901).
Culex sugens, Wiedemann, Aussereurop. zweifl. Ins. i, p. 545 (1828).

The white dots on the mesonotum, together with the white-ringed tibiae and tarsi, make this species an extremely easy one to recognise. The pre-apical spine of the male clasper, and the position of the siphonal tuft of the larva well beyond the middle, suggest that the species may have more in common with the subgenus *Ecculex* than with other species of *Stegomyia*, in spite of the spineless larval antennae and the slender, bare, upturned male palpi. The species affords a good illustration of the difficulty of drawing any hard and fast line between the subgenera of *Aëdes*, and confirms the inclusion of all of them in one comprehensive genus.

The larva has been recorded as occurring in rock pools.

Distribution.—Corsica (*Bigot*). Also widely distributed in the Ethiopian and Oriental regions, occurring as far south as Ceylon. It is remarkable that so conspicuous a species has not been found in the Mediterranean region since Bigot's time.

Genus **Armigeres**, Theobald.

This genus is evidently closely allied to *Aëdes* (especially the subgenera *Aëdes* and *Stegomyia*), so much so that scarcely any tangible differences can be discovered in the adults. The proboscis is rather short (not longer than the front femora) and is slightly but distinctly stouter throughout than in *Aëdes*; also the tip is slightly but distinctly curved downwards (at least in dry specimens), which is very seldom the case in *Aëdes*. In the allied Oriental genus or subgenus *Leicesteria* the mesonotum is somewhat produced over the head, and this tendency is slightly indicated also in the typical subgenus *Armigeres*. The structure of the eggs and manner of oviposition in *Armigeres* is similar to that of *Aëdes*; but *Leicesteria flava*, according to Strickland, has peculiar egg-laying habits. The male clasper has numerous spines, generally placed in a row (4–10 in *Leicesteria*, 15–20 in *Armigeres*). Another small point of distinction from *Aëdes* is that the middle claws of the male are apparently always equal and simple.

The main reason for keeping *Armigeres* distinct from *Aëdes* is the structure of the larval siphon, which has only a minute and often scarcely distinguishable hair-tuft, and no trace of a pecten. This latter point constitutes such a sharp difference from *Aëdes* that the separation from that genus may be justified, in spite of the feeble characterization of the adults. The anal gills are of large size and rounded apically.

The genus is endemic in the Oriental region, a single species extending into Japan and thus claiming our attention in this paper.

Armigeres obturbans (Walker).

Culex obturbans, Walker, Proc. Linn. Soc. London, iv, p. 91 (1860).
Culex subalbatus, Coquillett, Proc. U.S. Nat. Mus. xxi, p. 302 (1898).

Like the other species of the genus, this is a dark-coloured insect, with entirely dark tarsi and mainly white venter, and with flat scales, mostly dark, covering the head and scutellum. It differs from all its congeners in having a distinct if narrow band of black scales at the apex of each abdominal sternite. The male palpi resemble those of *Stegomyia*, but are entirely dark. I am indebted to Dr. H. G. Dyar for information as to the identity of Coquillett's type.

The larvae live in bamboo stems, and have been described by Banks (Phil. J. Sci., A. iii, p. 240, 1908). They have remarkably large, sausage-shaped anal gills, which enable them to remain long periods at the bottom.

Distribution.—Japan (Kofou, *L. Drouard de Lezey;* Kouy-Tchéou, *Fortunat;* Hakone, *E. Gallois;* Tokio, *Yamada*); also throughout the Oriental region, and extending into Celebes, New Guinea and North Australia.

Genus **Lutzia,** Theobald.

Owing to the highly modified larval mouth-parts and antennae, and the peculiar structure of the siphon and anal segment, it was long ago proposed by Christophers to separate the Old World species of this genus from *Culex* as a distinct genus (*Jamesia*); the same characters were used by Dyar and Knab in separating the New World *Lutzia* from *Culex*. In revising the African CULICIDAE in 1912 I did not accept this separation, owing to the apparent structural identity of the adults. I now find, however, that an excellent diagnostic character exists in the numerous lower mesepimeral bristles of *Lutzia*, and I therefore propose to revive this name. There is no real difference between the Old World and New World forms, and I consider Dyar's separation of *Jamesia* and *Lutzia* on a small detail of aedoeagal structure to be quite unjustifiable. The Old World species are all very similar, their separation resting on small differences of colour and venation.

Lutzia vorax, sp. n. (fig. 5 d).

Penultimate joint of male palpi with the integument and the hairs dark except at the extreme tip. Abdominal tergites in both sexes all with rather narrow but distinct apical pale ochreous bands. Lobes of mesosome of male aedoeagus enlarged beneath a little beyond the middle, the enlargement with some minute teeth; lobe of side-piece with three strong spines only. The whole of the outer side of the hind femora has the light and dark scales about evenly mixed. Cross-veins either in a straight line, or else m-cu (posterior) placed beyond r-m (mid).

L. concolor (R.-D.), Theo., the commonest form in the Oriental region, differs in having the last few abdominal segments entirely yellow-scaled, the yellow bands on the anterior segments narrower; the lobes of the mesosome are not enlarged beneath; the lobe of the side-piece usually has a fourth spine more or less developed, separate from the other three; the outer side of the hind femora is entirely pale at the base, from which a more or less definite pale line runs almost to the apex; and the cross-vein m–cu is placed at least slightly before r–m.

L. halifaxi (Theo.), known from the Malayan region and Queensland, has the hypopygium almost identical with that of *L. vorax*, the enlargement of the mesosomal lobes perhaps more prominent and practically in the middle; it differs in having the integument and hairs on the apical half or more of the penultimate joint of the male palpi paler than the basal part, and in having few or no pale scales on the apices of the abdominal tergites; the hind femora are as in *L. vorax*, but darker; the cross-veins, on the other hand, are placed as in *L. concolor*.

Dr. Lamborn found the larvae in old cess-pits preying upon *Culex fatigans*.

Distribution.—Japan (Tokio, *Yamada;* a series presented to the British Museum in 1916, determined at the time as *Culex concolor;* the type of the new species is one of the three males in this series; also Karuizawa, *Cornford,* and Nagasaki,

Lamborn). North India (Punjab, *Barrow*; female only). Probably widely distributed in the Oriental region, but confused with the two species above mentioned and with the Ethiopian *L. tigripes*.

Genus **Culex**, L.

This genus, I find, is sharply distinguished from almost all other mosquitos by the possession of distinct pulvilli. It is remarkable that the presence of these structures has been overlooked for so long; Howard, Dyar and Knab even state positively that they are absent throughout the family; these and other writers must either have omitted to study *Culex* closely, or else have used an insufficient magnification. I have examined a large number of species of this genus, and find pulvilli present in all; they do not vary much in size, but are naturally more easily detected in the larger species. Figs. 5 d and 5 e (made with the aid of a camera lucida) show clearly the different appearance under a sufficiently high power between a hairy empodium and a pair of true pulvilli. In the front and middle tarsi of the male the pulvilli, like the claws, are elongated, and therefore less noticeable; they may be seen, however, on the hind tarsi as well as on all the feet of the female. The only other mosquitos which possess pulvilli are the genera which on other grounds have already been regarded as close allies of *Culex*: *Culiciomyia, Lophoceratomyia, Micraëdes Carrollia, Lutzia,* and *Deinocerites* (including *Dinomimetes*). The first three or four of these should not be regarded as more than subgenera of *Culex*, though the last two may be treated as distinct genera.

The following characters are also common to most if not all species of *Culex*; some of these will further help to distinguish the members of this genus from *Aëdes*: Eyes very narrowly separated or even touching for a considerable length above the antennae. Proboscis not or scarcely longer than the front femora. Male palpi when long always slender, with the last two joints upturned. Male antennae always plumose, with the hairs spreading out evenly all round. Spiracular and post-spiracular bristles absent. Usually only one lower mesepimeral bristle or none; very rarely two or three. Female abdomen blunt-ended, the cerci short and broad, eighth segment not at all retractile. Male hypopygium without claspettes or basal lobes to the side-pieces, but with subapical lobes bearing modified bristles. Tenth sternites ending in a tuft or comb of spines. Mesosome a paired structure with pointed processes. Claspers articulating in a more or less vertical plane. First joint of hind tarsus as long as the tibia or slightly longer. Female claws always simple. Wings with distinct microtrichia on the membrane; cell R_2 markedly longer than its stalk in the female; vein A_{ii} ending much beyond the level of the base of R_s.

Larva.—Antennae with a distinct hair-tuft, which is generally well beyond the middle, the part of the antenna beyond the tuft usually rather suddenly narrowed, and with few or no spinules; two long preapical spines. Hairs of mouth-brush simple. Frontal hairs rarely if ever single, and never placed one in front of the other. Anal segment with a complete chitinous ring (in the fourth stage only). Siphon with numerous ventral tufts, or else greatly elongate.

The genus is essentially tropical and sub-tropical, only a very few species extending into the temperate regions. Only *C. apicalis* and the domestic *C. pipiens* and *C. fatigans* are common to Europe and North America.

Three fairly well-marked subgenera occur within the Palaearctic region, as indicated in the following keys.

Adults.

1. First joint of hind tarsi distinctly shorter than the tibiae; small obscurely coloured species (*Barraudius*) 2
   First joint of hind tarsi scarcely, if at all, shorter than the tibiae .. 3

2. Abdominal tergites with continuous lateral pale stripes .. *modestus*, Fic.
Abdominal tergites, with basal lateral pale patches.. .. *pusillus*, Mcq.

3. A row of small flat white scales round the margin of the eyes (*Culicomyia*) *impudicus*, Fic.
Scales on the top of the head all narrow (*Culex*) 4

4. Prothoracic lobes and pro-epimera with numerous broad flat scales; pale bands of abdominal tergites apical (occasionally reduced to lateral spots) 5
Prothoracic lobes and pro-epimera with few or no flat scales 6

5. Hind tibia with a distinct white spot on the outer side at the tip, *hortensis*, Fic.
No such spot .. .. *apicalis*, Adams.

6. Dorsum of abdomen uniformly dark brown; species without ornamentation *hayashi*, Yam.
Abdominal tergites at least with basal lateral patches of pale scales .. 7

7. Proboscis and tarsi pale-ringed.. 8
Proboscis and tarsi without pale rings 14

8. Anterior two-thirds, or at least the middle third, of the mesonotum with whitish scales, which contrast sharply with the dark scales of the posterior third 9
Thorax not so marked 11

9. Femora and tibiae with numerous small but conspicuous pale dots; abdominal tergites with basal pale bands or spots only *quasigelidus*, Theo.
Femora and tibiae with the scales mottled, but without conspicuous pale dots; abdominal tergites with apical pale bands 10

10. Wings with numerous pale scales .. .. .. *bitaeniorhynchus*, Giles.
Wing-scales all dark .. .. *sinensis*, Theo.

11. Wings with conspicuous pale markings 12
Wings unmarked 13

12. Tip of vein Cu_2 (lower branch of fifth) dark-scaled .. .. *mimeticus*, Noé.
Tip of vein Cu_2 pale-scaled .. .. *orientalis*, sp. n.

13. Mesonotal scales all dark reddish-brown, except perhaps round the margin; middle tibiae without any trace of a pale stripe .. *tritaeniorhynchus*, Giles.
Mesonotal scales mixed light and dark brown; middle tibiae with a pale anterior longitudinal stripe more or less indicated .. *vishnui*, Theo.

14. Femora and tibiae with distinct pale longitudinal stripes anteriorly (most marked on front and middle legs).. 15
Femora and tibia not striped 16

15. Mesonotal scales dark brown, more or less mixed with lighter; pale abdominal bands generally triangularly produced in the middle *tipuliformis*, Theo.
Mesonotal scales reddish-brown; pale abdominal bands gently rounded *virgatipes*, Edw.

16. Abdominal tergites with complete basal pale bands 17
Abdominal tergites with basal pale lateral spots only 20

17. Abdominal bands white 18
Abdominal bands pale ochreous 19

18. Pale abdominal bands very broad; hind tibiae dark except at tip *laticinctus*, Edw.
Pale abdominal bands narrow; hind tibiae with a more or less distinct pale lateral stripe .. .. *perexiguus*, Theo

19. Mesonotal scales ochreous-tinged .. .. *fatigans*, Wied.
Mesonotal scales generally reddish-brown .. .. *pipiens*, L.
20. Upper fork-cell in female with a very short stalk; last two joints of male palpi with a white line beneath .. .. .. *pipiens*, L., var.
Upper fork-cell in female with a longer stalk; last two joints of male palpi dark beneath .. .. *laurenti*, Newst.

Male Hypopygia.

1. Side-piece with scales, the lobe scarcely if at all beyond the middle, without flattened plate (*Barraudius*) 2
Side-piece without scales, the lobe well beyond the middle.. 3
2. Clasper long and slender .. .. *modestus*, Fic.
Clasper shorter and stouter .. .. *pusillus*, Macq.
3. Clasper with a conspicuous spiny crest (?); side-piece with a large and conspicuous tuft of hairs projecting outwards (*Culiciomyia*), *impudicus*, Fic.
Clasper without conspicuous subapical spiny crest; side-piece without conspicuous hair-tuft (*Culex*) 4
4. Lobe of side-piece without an apically situated flattened plate 5
This plate present, or represented by several.. 6
5. Side-piece with an apical finger-like process; appendages of lobe short *hortensis*, Fic.
Side-piece without finger-like process; appendages of lobe long, *apicalis*, Adams.
6. Lobe of side-piece with several flattened plates .. .. *hayashi*, Yam.
Lobe of side-piece with only one flattened plate 7
7. Plate on lobe of side-piece narrow and pointed 8
The plate broad, rounded, and leaf-like 10
8. Tenth sternites without basal arm .. .. .. *quasigelidus*, Theo.
Tenth sternites with well-developed basal arm 9
9. Mesosome formed of two pairs of upwardly-directed, sickle-shaped structures; basal arm of tenth sternites short .. *bitaeniorhynchus*, Giles.
Mesosome formed of one pair of pointed, almost straight structures; basal arm of tenth sternites long .. .. *sinensis*, Theo.
10. Side-piece with dense hairs round the tip and near the lobe 11
Tip and region near lobe of side-piece not densely hairy 12
11. Clasper greatly widened in the middle, ending in a long, sharp point *orientalis*, sp. n.
Clasper not much widened in the middle .. .. .. *laticinctus*, Edw.
12. Basal arm of tenth sternites well developed 13
Basal arm of tenth sternites very short or absent 19
13. Clasper sickle-shaped, gradually tapering to the tip 14
Clasper somewhat broadened beyond the middle 18
14. Mesosome elaborately divided, the two main divisions each further split up 15
Mesosome much more simple 17
15. Lower division of mesosome with only two or three teeth, which are turned outwards .. .. *mimeticus*, Noé.
Lower division of mesosome with 4–6 teeth, which are spread out finger-like or curved tailwards 16
16. Innermost tooth on mesosome considerably longer than the rest *tritaeniorhynchus*, Giles.
All the teeth approximately equal in size .. .. .. *vishnui*, Theo.

17. Mesosome with two divisions, one of which carries two or three short teeth *tipuliformis*, Theo.
Mesosome (as seen from above) with three simple divisions .. *virgatipes*, Edw.

18. Second division of mesosome simple .. .. *perexiguus*, Theo.
Second division of mesosome divided into several teeth .. *laurenti*, Newst.

19. Second division of mesosome very broad and plate-like .. *fatigans*, Wied.
Second division of mesosome narrow and hook-like .. .. *pipiens*, L.

Larvae.

1. Siphon rather less than three times as long as broad 2
Siphon at least four times as long as broad, generally much more .. 3

2. Siphon pale, all the tufts arranged in a slightly zigzag mid-ventral line; tip of antennae black and much narrowed .. *pusillus*, Mcq.
Siphon blackish; ventral tufts in three or four pairs, the members of which are widely separated; two lateral tufts also present; antennae all pale, tip scarcely narrowed .. [*nebulosus*, Theo.], *impudicus*, Fic.

3. Comb of eighth segment with 4–8 large sharp teeth 4
Comb of eighth segment with numerous small scales in a triangular patch.. 5

4. Siphon with a dark ring at one-third of its length; head very dark; pecten-teeth 6–9 .. .. *quasigelidus*, Theo.
Siphon and head pale; pecten teeth only 2–3 .. *bitaeniorhynchus*, Giles.

5. Siphonal tufts 8–10, in a zigzag ventral row, the first two or three tufts between the pectens .. .. *laticinctus*, Edw.
Siphonal tufts more or less paired, none between the pectens 6

6. Siphon 6–7 times as long as its breadth at the base; or, if a little shorter (*C. tipuliformis*), the pecten teeth have short basal denticles only .. 7
Siphon 4–5 times as long as its breadth at the base; pecten teeth with rather long denticles extending more than half their length 12

7. Pecten spines strong, curved, rather wide apart, with small basal denticles *tipuliformis*, Theo.
Pecten spines smaller, straight and closer together, generally with more numerous denticles 8

8. Siphon distinctly enlarged at the tip, tufts few and small .. *apicalis*, Adams.
Siphon not enlarged at the tip 9

9. Siphonal tufts rather numerous, some much longer than the diameter of the siphon 10
Siphonal tufts fewer, none longer than the diameter of the siphon.. .. 11

10. Antennae pale except on the portion beyond the subapical bristles, which is nearly as long as the part between these bristles and the tuft *mimeticus*, Noé.
Antennae entirely, or at least more than half, dark, subapical bristles quite near tip .. .. *hortensis*, Fic.

11. Antennal tuft at two-thirds; siphonal tufts all subventral (paired) *tritaeniorhynchus*, Giles.
Antennal tuft beyond two-thirds; two pairs of siphonal tufts lateral *perexiguus*, Theo.

12. Siphon about 5×1, pecten teeth averaging 12–15 .. .. *pipiens*, L.
Siphon scarcely 4×1, pecten teeth averaging 9 .. .. *fatigans*, Wied.

Subgenus **Barraudius**, nov.

First joint of hind tarsus distinctly shorter than the tibia. No flat scales on top of head adjoining eyes. Side-pieces of male hypopygium with numerous small scales on the outer side ; lobe situated scarcely beyond the middle, without flattened plate, and with only two or three stout spines. Clasper without subapical spiny crest. Larval mouth-parts normal, not modified for predacity. Siphonal hair tufts arranged mid-ventrally in a single very slightly zigzag line which runs the whole length. Anal segment short, as in typical *Culex*. Type species: *Culex pusillus* (Macq.), Storey.

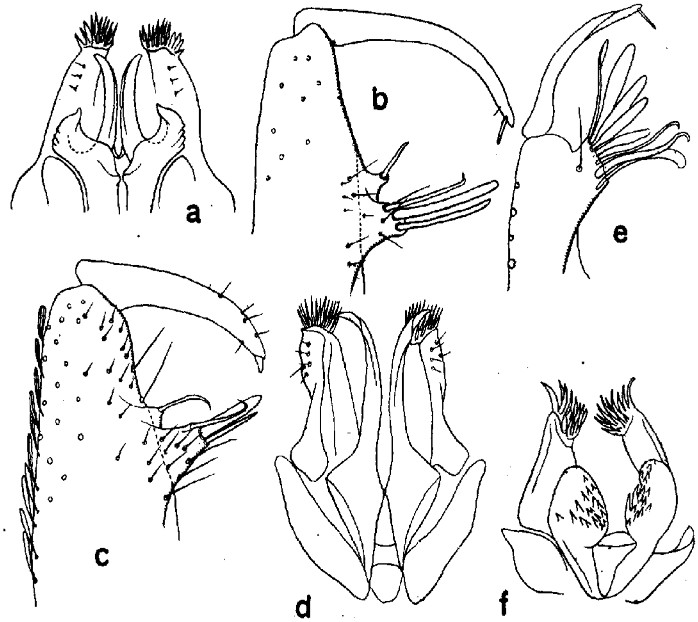


Fig. 12. Hypopygia of Palaearctic species of *Culex*: a, d, f, basal parts, dorsal view; b, c, e, tips of side-pieces, lateral view, all ×200. a, b, *C. modestus*, Fic.; c, d, *C. pusillus* (Macq.), Storey; e, f, *C. hayashi*, Yamada.

The erection of this subgenus is necessary for the reception of two small obscure species from the eastern Mediterranean region. By several of the characters enumerated above they appear to be more distinct from typical *Culex* than any other groups occurring in the Old World.

1. **Culex (Barraudius) modestus** (Fic.) (fig. 12 a, b).

Culex modestus, Ficalbi, Bull. Soc. Ent. Ital. xxi, p. 293 (1890), and xxxi, p. 211 (1899).

Apart from the tarsal character mentioned in the key, the female of this species is not easy to distinguish from the unbanded variety of *C. pipiens*. There is, however, no connection between the two species, which are as widely separated in the structure of the male hypopygium as any two species of the genus. The average size is smaller

than the smallest *C. pipiens*, the integument of the thorax is generally paler and the scales browner. The long, bare male palpi will at once distinguish that sex from *C. pipiens* as well as from all other Palaearctic species except *C. pusillus* and *C. hortensis*. The pale markings of the abdomen have an ochreous tint; the colours of the tergites are either separated in a straight line, or the pale lateral stripes are slightly enlarged apically.

Distribution.—Italy (*Ficalbi*); Hungary (*Kertész*; also Neusiedler See, *Mik*); Macedonia (*Waterston*); Asia Minor (Salyr, Konia and Bashara, *Naday*); Palestine (marsh at Tel Abu Zeitun, *Austen*); perhaps the species recorded from Rumania by Leon as *C. fusculus*.

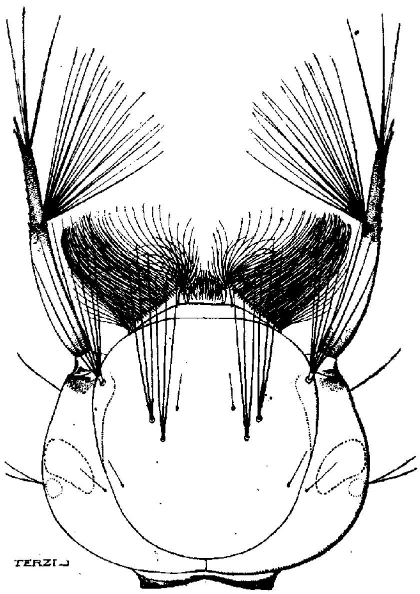


Fig. 13. *Culex pusillus* (Macq.) Storey, head of larva.

2. **Culex (Barraudius) pusillus** (Macq.) Storey (figs. 12 c, d, 13, 14).

Culex pusillus, Macquart, Dipt. Exot. Supp. iv, p. 9 (1850).
Culex pusillus, Storey, Bull. Soc. Ent. Egypte 1918, (1919).

I did not at first distinguish this species from *C. modestus*, and it was recorded by Barraud under this name. It closely resembles *C. modestus*, but differs quite markedly in the male hypopygium. The claspers are shorter and stouter, there are differences in the lobe of the side-piece, and the anal and genital parts are much more elongate and rather differently constructed. The pale markings of the abdomen are pure white, and thus differ in colour as well as in form and position from those of *C. modestus*.

I have examined the original specimens of Macquart's *C. pusillus*, one of which is in the Vienna Museum and the rest in the Bigot collection in Mr. Collin's possession.

All are in such bad condition that they are totally unrecognisable, but from their size there is no reason to suppose that Storey's identification is incorrect.

The larva was found by Barraud in small numbers near Basra. The accompanying figures have been prepared from a comparison of two mounted skins presented by him to the British Museum. The extremely short siphon, with all the hair-tufts placed in a slightly zigzag row in the mid-ventral line, is very remarkable, and very suggestive of the siphon of *Lutzia*, to which genus *C. pusillus* and *C. modestus* also

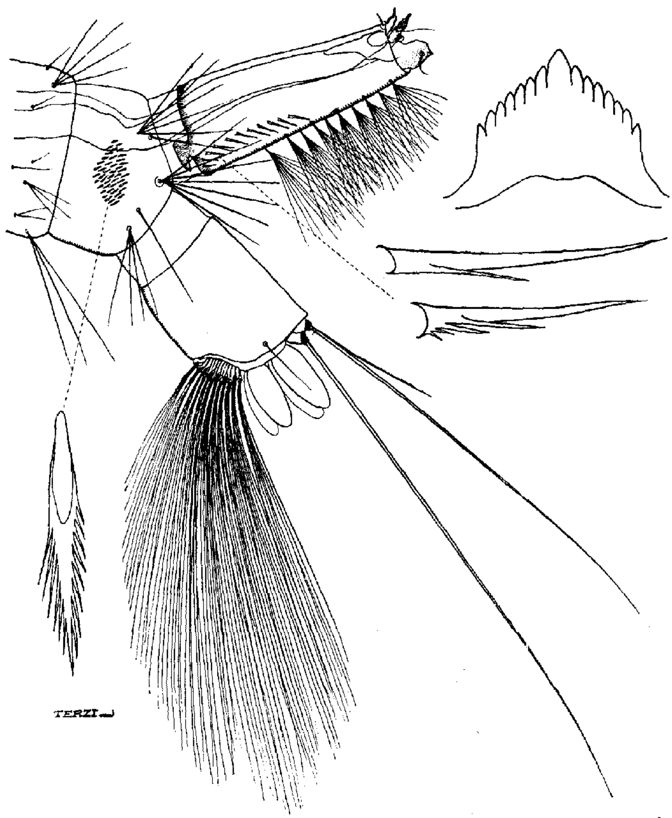


Fig. 14. *Culex pusillus* (Macq.) Storey, end of abdomen of larva; comb and pecten teeth and mentum more highly magnified.

show a marked resemblance in the structure of the male hypopygium. There is no sign, however, of any modification of the larval mouth-parts for predaceous habits, and the anal segment is differently shaped.

Distribution.—Egypt (*Storey*). Mesopotamia (*Barraud*).

Subgenus **Culiciomyia,** Theo.

Head in both sexes with a narrow rim of small flat scales along the upper orbital margin. Male palpi with a row of long scales projecting inwards from the apical

half or more of the long joint; the scales are of peculiar shape, sharply pointed at the tip and more or less widened about the middle. Lobe of side-piece of male hypopygium with two flat plates. Clasper with a conspicuous spiny crest at some distance before the tip, which is rather suddenly narrowed. Tips of tenth tergites with the inner spines slender and sharp-pointed, the outer ones much stouter and blunter. Otherwise as in *Culex*, s. str.

None of the distinctions mentioned above are fundamental, and it may be doubted if the subgenus is worth maintaining. The rather well-marked larval characters of *C. nebulosus* are not shared by the Oriental members of the subgenus.

One species apparently occurs in the Mediterranean region; another (*C. pallidothorax*, Theo.) is common in south China, and should be looked for in Japan. There are other Oriental and Ethiopian species, but none in Australia or America. In the New World the type is represented by *Choeroporpa*, Dyar.

3. **Culex (Culiciomyia) impudicus,** Ficalbi.

Culex impudicus, Ficalbi, Bull. Soc. Ent. Ital. xxii, p. 81 (1890), and xxxi, p. 214 (1899).

(?) *Culiciomyia nebulosa* (Theobald) Edwards, Bull. Ent. Res. ii, p. 254 (1911).

I do not know *Culex impudicus* except from Ficalbi's works, but his figures of the male hypopygium are so much like the structure to be found in some specimens of *C. nebulosus*, Theo., from the Gold Coast* that I feel certain *C. impudicus* must be a *Culiciomyia* closely related to the African species, and it even seems possible that the apparent differences may be due to inaccuracies in Ficalbi's figures. This conclusion is rendered more probable by the fact that I have examined two females of a *Culiciomyia* indistinguishable from *C. nebulosus* in the Paris Museum collection from Beirut (*Dr. Landrieu*). The species should therefore be determinable easily by the characters mentioned under the subgenus. It is an almost uniformly dark species, with small pale spots at the apical corners of the abdominal tergites.

According to Ficalbi the larvae of *C. impudicus* were found in water-holes with much vegetation used for irrigating gardens in Sardinia, and in large marshes in Sicily. In West Africa *C. nebulosus* breeds in any small collection of water, especially about houses; it is sometimes found in tree-holes and bamboos.

Subgenus **Culex,** s. str.
(including *Neoculex*, Dyar).

Head without any small flat scales in the middle in front. Male palpi without a row of outstanding scales on the long joint. Usually 5–7 pro-epimeral bristles, some smaller than others. First joint of hind tarsus as long as the tibia, or very slightly longer or shorter. Side-pieces of male hypopygium without scales, the lobe well beyond the middle, normally with a flat plate as well as four or five modified bristles. Clasper without definite spiny crest. Larva with the siphonal tufts more or less paired, not all in the mid-ventral line, no tufts on basal fourth or more of siphon.

The members of this subgenus exhibit a fair amount of diversity, but it does not seem to me that any groups are sufficiently circumscribed to be treated as subgenera. Dyar's *Neoculex* (to which belong *C. hortensis* and *C. apicalis*) cannot be defined on any larval character, while even the hypopygial characters on which it is based are closely approached by *C. sinensis*, from which species by slight gradations (through *C. quasigelidus* and other allied forms) the typical *Culex* structure is soon reached.

* There are, I find, two definite varieties or species of *Culiciomyia* in Africa, distinguishable by hypopygial differences. I have not yet estimated the precise relationship of these two nor their distribution. If either is synonymous with *C. impudicus* it will of course have to take Ficalbi's name, but it is perhaps more likely that the Mediterranean form is distinct.

4. **Culex hortensis,** Ficalbi.

Culex hortensis, Ficalbi, Bull. Soc. Ent. Ital. xxi, p. 27 (1889), and xxxi, p. 217 (1899).
Maillotia pilifera, Theobald, Mon. Cul. iv, p. 274 (1907).
Culex geniculatus, Theobald (*nec* Olivier), Mon. Cul. iii, p. 216 (1903).

Easily distinguished from the other Palaearctic species with dark tarsi by the apically situated bands on the abdominal tergites and from its ally *C. apicalis* by the white spot at the tip of the hind tibia, and the bare male palpi. The abdominal bands are variable in width, being reduced occasionally to lateral spots only.

The larvae are said to prefer weedy ponds, particularly those covered with duckweed.

Distribution.—Throughout the Mediterranean region and central Europe, extending as far north as Paris and Berlin. Some new records are: Corsica (*Mann*); Asia Minor (Ereckli, Sabanja, *v. Bodemeyer*); Germany (Berlin, Schildhorn, *Oldenberg*, 1 ♀); Transcaspia (Firudza, *C. Ahnger*); Syria (Beirut, *Landrieu*).

5. **Culex apicalis,** Adams.

Culex apicalis, Adams, Kansas Univ. Sci. Bull. ii, p. 26 (? June 1903).
Culex sergenti, Theobald, Mon. Cul. iii, p. 218 (July 1903).
Culex pyrenaicus, Brolemann, Ann. Soc. Ent. France, lxxxvii, p. 427 (1919).
Culex territans, Howard, Dyar & Knab, Monogr. iv, p. 293 (1912) (*nec* Walker).

In spite of the great differences in the male hypopygium, there can be no doubt that this is closely related to *C. hortensis*. The most obvious distinctions of *C. apicalis* are the hairy terminal joints of the male palpi and the dark tip of the hind tibia. The wing-scales seem to be a little narrower, and the pale abdominal bands are also perhaps on the average narrower. It may not always be possible to distinguish the females with certainty; Eckstein states that they differ from those of *C. hortensis* in having the bases of the abdominal sternites dark-scaled, but I cannot confirm this.

The larva differs from that of *C. hortensis* in the bicoloured antennae, in the shape of the siphon, and in the smaller and less numerous siphonal tufts. The two species are said by Séguy to breed under similar conditions, though according to Eckstein *C. apicalis* is found in clear water.

Distribution.—Occurs over a wide area in Europe and North America, apparently also in North Africa, though I have seen only females from there (including Theobald's type of *C. sergenti*) and am not absolutely certain of their identity. Some new records are: Tunis (Tamerza, *Langeron*, ♀); Italy (Gorizia, *Mik*, ♂ ♀); Carniola (Wippach, *Handlirsch*); Transcaspia (Amudaria, *C. Ahnger*).

6. **Culex hayashi,** Yamada (fig. 12 e, f).

Culex hayashi, Yamada, Dobuts. Z. Tokio, xxix, pp. 61–72 (1917).

This differs from all other species known from the Palaearctic region in having the male palpi straight and considerably shorter than the proboscis (about three-quarters as long), but there are several other Oriental species with which it might be confused, such as *C. brevipalpis* (Giles) and *C. jenseni* (Meij.). The male hypopygium is also very distinct, on account of the structure of the mesosome and the numerous plates on the lobe of the side-piece; in the former point *C. hayashi* much resembles the subgenus *Lophoceratomyia*, but it does not show any modification of the male antennae, nor any flat scales on the top of the head; it should perhaps be placed in Dyar's subgenus *Neoculex*, if that is adopted. The species is unicolorous brown, only the lower side of the abdomen somewhat lighter. The scaling is that of a normal *Culex*, but there seem to be some flat scales on the prothoracic lobes.

Dr. Lamborn found the larvae in muddy pools in company with those of *Anopheles punctibasis*.

Distribution.—Japan (Tokio, *Yamada*, a series presented by the collector to the British Museum in 1915; Nagasaki, *Lamborn*).

7. **Culex quasigelidus,** Theobald.

Culex quasigelidus, Theobald, Mon. Cul. iii, p. 181 (1903); Edwards, Bull. Ent. Res. ii, p. 258 (1911).

This is one of the most distinct members of a rather large group of tropical species, which Theobald included in his genus *Leucomyia*. The leg markings are distinctive, but are not at all unlike those of the Old World species of *Lutzia*, especially *L. tigripes*, of which *C. quasigelidus* has been taken to be a variety, though in reality it is very different. The larvae, like many others with long siphons, live in weedy pools; they are very similar in structure to those of the other members of this group.

Distribution.—Widely spread in the Ethiopian region, occurring in Madagascar, and spreading northward by the Nile valley as far as Alexandria.

8. **Culex bitaeniorhynchus,** Giles.

Culex bitaeniorhynchus, Giles, J. Bombay Nat. Hist. Soc. xiii, p. 607 (1901); Edwards, Bull. Ent. Res. iv, p. 231 (1913).

The wing-scales of this species are unusually broad for a *Culex*, and on this account Theobald placed it in the genus *Taeniorhynchus*, with which it has really no connection. Usually the pale scales on the wings are almost as numerous as the dark ones, at least in the female, but a variety occurs in which they are comparatively few and scattered. The femora and tibiae are also very much mottled. The pale bands of the abdomen are very variable in width; they may be very narrow, or the abdomen may be almost all pale. The species is semi-domestic, the larva often living in polluted water.

Distribution.—Throughout the Oriental region; occurring also in Japan and North Australia. A variety, differing slightly in the male hypopygium, is widely spread in Africa.

9. **Culex sinensis,** Theobald.

Culex gelidus var. *sinensis*, Theobald, Mon. Cul. iii, p. 180 (1903).
Leucomyia sinensis, Theobald, Mon. Cul. v, p. 313 (1910).
Culex sinensis, Edwards, Bull. Ent. Res. iv, p. 231 (1913).

This is at first sight very much like *C. bitaeniorhynchus*, but differs in the much narrower and entirely dark wing-scales, and very considerably in the male hypopygium. Apart from this, the femora and tibiae are less mottled, the pale scales which are present tending to be aggregated into small dots, though these are not nearly so conspicuous as in *C. bitaeniorhynchus*.

Distribution.—Widely spread in the Oriental region, and, like the last species, occurs also in Japan (Tokio, *Yamada*), but is not known from Australia or Africa, where it seems to be represented by allied but distinct species.

10. **Culex mimeticus,** Noé.

Culex mimeticus, Noé, Bull. Soc. Ent. Ital. xxxi, p. 240 (1899).

A very interesting species on account of the spotted wings, the markings comprising three pale ochreous areas on the costa, which extend on to the first vein,

also other pale areas, the most noticeable of which are in the middle of the third vein and towards the base of the sixth. The fifth vein is entirely dark, except for a part of its upper branch. The wing-scales are narrow but rather short. The proboscis has a well-defined pale ring about the middle in both sexes. The male palpi have pale rings at the bases of the last two joints and a very narrow one at the tip of the last joint. The side-pieces of the hypopygium are only moderately hairy ; the lobe with the usual five modified bristles (the apical one unusually flattened and outwardly directed) and leaf-like plate ; clasper sickle-shaped, gently tapering, with well-marked terminal claw ; tenth sternites with the basal arm quite long, though shorter than the sternites ; second division of mesosome split into two or three teeth.

The larva has been partly described and figured by Martini, but he has omitted to notice an important point, the position of the pair of subapical antennal bristles only a little more than mid-way between the tuft and the apex of the shaft. It is also noteworthy that the pale colour of the antenna extends some way beyond the tuft, almost to the subapical bristles. The 4 or 5 pairs of larger siphonal tufts are at least twice as long as the diameter of the tube. The larva is remarkably like that of *C. hortensis*, differing in antennal characters and in the rather greater number of siphonal tufts ; the latter point is probably not of much importance, as the number and also the position of the tufts is certainly variable in many species of the genus.

The most interesting fact about this species is its occurrence in association with *Anopheles superpictus*, to which it bears a considerable resemblance in wing-markings. Whether we have a genuine case of mimicry, and if so what advantage the species could gain by it, I will not attempt to judge, but it is perhaps an even more remarkable fact that the allied *C. mimulus*, which differs in having a dark third vein, occurs with *Anopheles culicifacies* or *A. minimus*, which differ in the same way from *A. superpictus*.

Distribution.—Mountainous regions in the eastern Mediterranean region. Italy (*Noé*) ; Macedonia (*Martini, Waterston*) ; Palestine (*Cropper*) ; Cyprus (*Miss Bate*).

The species was till recently supposed to have a much more extended distribution, but I have recently shown that the form inhabiting Ceylon and Malaya differs slightly both in wing markings and hypopygial details, and have therefore treated it as a distinct species, *C. mimulus*. There are good larval differences between *C. mimeticus* and *C. mimulus*, the latter having few and short siphonal tufts, and the subapical antennal bristles close to the tip. A second form, which is probably equally distinct, is found in Hong Kong, Formosa, and South India (Ootacamund, recorded by me recently as *C. mimeticus*). This differs from the true *mimeticus* in the much broader pale tip to the longer male palpi, the absence (apparently not quite constantly) of the basal arm of the tenth sternites, and perhaps in other details. I have seen only females from North India, and cannot say whether they belong to this second Oriental form or to the true *mimeticus*. The Japanese form must obviously be treated as another quite distinct species.

11. **Culex orientalis,** sp. n.

Differs from *C. mimeticus* as follows :—Wing-scales somewhat broader and distinctly longer, the wings therefore appearing more densely scaled. Cu_2 (lower branch of fifth vein) with a pale area at its tip, most noticeable in the female ; another pale area (more or less developed) before the fork. Male proboscis with numerous pale scales on the apical portion beyond the ring, sometimes the whole apical portion is pale. Hypopygium : side-pieces large and stout, densely hairy, especially round the somewhat produced tip and near the lobe ; lobe with eight somewhat flattened appendages, all much alike, with rounded, not hooked tips, and placed almost in a continuous row ; besides these there are numerous accompanying long hairs ; leaf-like plate and its accompanying bristle present as usual. Clasper

very large, flat, very much broadened a little beyond the middle, ending in a rather long sharp point; terminal claw very minute; subapical spiny crest slightly indicated. Tenth sternites with moderate basal arm. Second division of mesosome with three rather large teeth and about five small ones.

The hypopygium is more like that of *C. laticinctus* than that of *C. mimeticus*. It would be of interest to know whether there is any similar resemblance in the larvae.

Distribution.—Japan (Tokio, *Yamada*). A series presented by the collector to the British Museum in 1915 was determined by me then as *C. mimeticus*, but a closer study reveals the striking differences enumerated above. Also Yokohama and Kobe (*Lamborn*); the larvae in rice-fields in company with *Anopheles hyrcanus*.

12. **Culex tritaeniorhynchus,** Giles.

Culex tritaeniorhynchus, Giles, J. Bombay Nat. Hist. Soc. xiii, p. 606 (1901); Edwards, Bull. Ent. Res. iv, p. 233 (1913), and vii, p. 224 (1917).

This species is sufficiently distinguished by the characters mentioned in the key, but I have given a number of others in the papers quoted above. The average size is very small (3 mm.), but in this respect the species varies a good deal in different parts of its range, Japanese examples being much larger than those from Palestine.

Larvae have been received from Capt. Barraud from Mesopotamia; they are remarkably similar to those of *C. perexiguus*, described below; I can discover very few differences beyond those mentioned in the key, which seem most likely to be constant. Other larvae from Ceylon differ slightly from these, but not to such an extent that they need be separated specifically. They are found usually in salt marshes, often in company with other small species with a banded proboscis (*C. vishnui* or *C. sitiens*).

Distribution.—Palestine and Mesopotamia (*Barraud*); Palestine (Khirbet Hardrah, *Austen*; Jerusalem, *Goldberg*); Japan (Tokio, *Yamada*; Chuzenji, *Gallois*; Nagasaki, *Lamborn*); China (Shanghai, *Lamborn*, etc.). Also throughout the Oriental region and on both the east and west coasts of Africa.

13. **Culex vishnui,** Theobald.

Culex vishnui, Theobald, Mon. Cul. i, p. 355 (1901); Edwards, Bull. Ent. Res. iv, p. 233 (1913), and vii, p. 225 (1917).

In spite of the very slight difference in the hypopygia (there are perhaps some other slight distinctions besides the one mentioned in the key) I feel sure this species is distinct from *C. tritaeniorhynchus*, its closest ally and frequent associate. *C. vishnui* breeds in rice-fields, salt-marshes, and elsewhere. No isolated larvae have been received at the British Museum, nor has a description of the early stages been published. The hypopygium is very similar to that of *C. mimulus*.

Distribution.—Mesopotamia (*Barraud*); Japan (Osaka, *Theobald*). Also throughout the Oriental region, but as yet unknown from Africa.

14. **Culex tipuliformis,** Theo. (figs. 15, 16).

Culex tipuliformis, Theobald, Mon. Cul. ii, p. 325 (1901); Edwards, Bull. Ent. Res. ii, p. 262 (1911), and iii, p. 31 (1912).
Culex creticus, Theobald, Mon. Cul. iii, p. 189 (1903).

Apart from the striped femora and tibiae, and the more or less produced abdominal bands, this might easily be mistaken for *C. pipiens*, especially in rubbed specimens. It is, however, generally darker in colour, the upper fork-cell is not so long, and the

cross-veins, though variable in position, tend to be more approximated than in *C. pipiens*, being occasionally almost in one line. As in *C. pipiens*, the last two joints of the male palpi have whitish markings beneath, but in this species the pale scales tend to be arranged more in patches, one of which is at the tip of the last joint.

The larva has been described by Bedford from the Transvaal (U.S. Afr. Dept. Agr., 5th & 6th Repts. Director Vet. Res., 1919, p. 741), his description and figure agreeing in the main with specimens I have examined, though he shows shorter and more numerous tufts on the siphon. The accompanying figures are based on Capt. Barraud's material. The siphon is distinctly longer than that of *C. pipiens*, index about 5·5–6.* The pecten teeth are 6–9 in number, but rather widely spaced, and reaching beyond a third of the length of the siphon. The first few teeth are quite small, but the last four or five are long, curved, and almost simple, only one or two small basal denticles being present. The antennae are dark at the tip and at the extreme base, pale in the middle, the tuft being placed at about three-fifths. The head is more or less extensively dark basally. The siphon

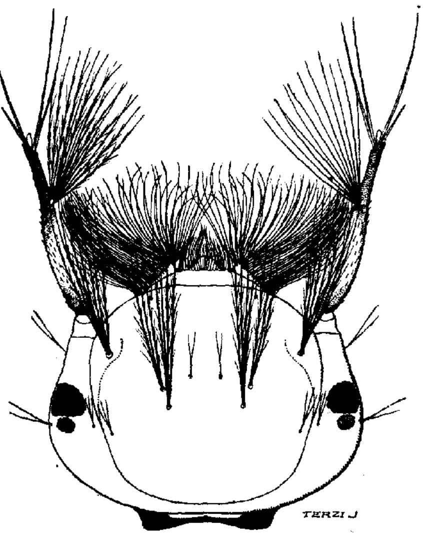


Fig. 15. *Culex tipuliformis*, Theo., head of larva.

is generally all pale, but among the specimens sent by Capt. Barraud from Mesopotamia there are several which have the basal half of the siphon dark or even black; these specimens also appear to have the siphon a little shorter than usual, but the adults issuing from them do not differ appreciably from normal *C. tipuliformis*.

Distribution.—Atlantic islands; Mediterranean region generally; extending through East Africa to the Cape and by way of Persia into north India and Assam;

* By the siphonal index I mean the ratio of the diameter of the *base* of the siphon to the length, the valves not being reckoned into the length. Séguy apparently takes the ratio of the *average* width to the length.

a rather remarkable distribution, which is exactly parallelled by that of *Theobaldia longiareolata*. I believe the following are new records:—Asia Minor (Konia and Bashara, *Naday*) ; Persia (Enzeli, *Buxton*) ; West Caspian (Lenkoran, *Karsch*) ; Libyan Desert (Bulag, *W. J. H. King*).

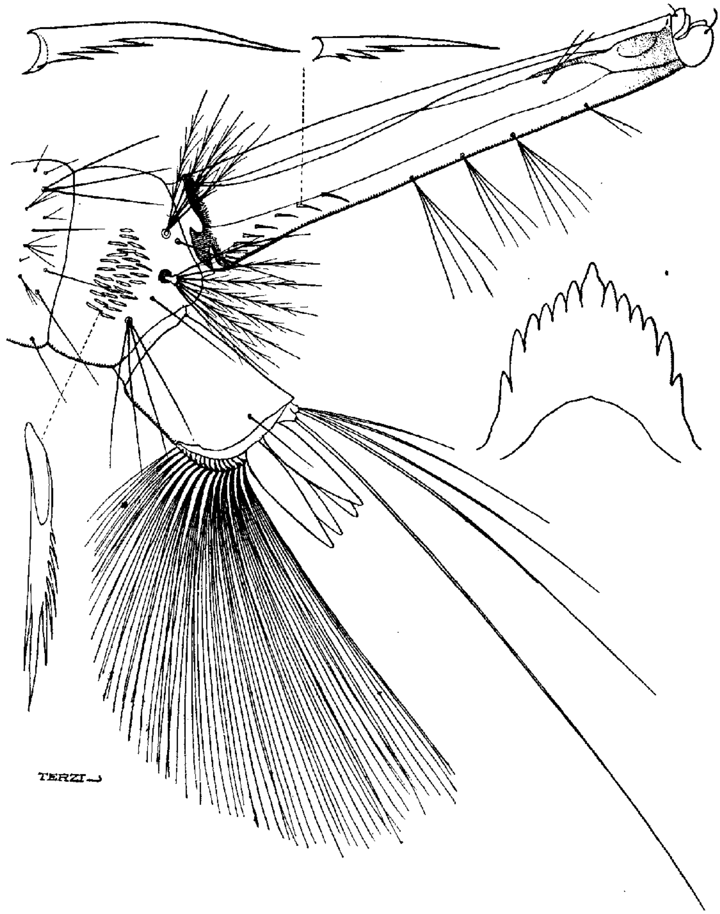


Fig. 16. *Culex tipuliformis*, Theo., end of abdomen of larva ; comb and pecten teeth and mentum more highly magnified.

15. **Culex virgatipes**, Edw.

Culex virgatipes, Edwards, Bull. Ent. Res. v, p. 126 (1914).

Differs from *C. tipuliformis* in the male hypopygium, which is extremely similar to that of the African *C. trifilatus*, Edw., in the uniformly reddish-brown mesonotal scales and in the abdominal markings. The cross-veins are on the average more

widely separated than in *C. tipuliformis*, and the femoral and tibial stripes, though quite distinct, are rather narrower in this species. The resemblance to *C. pipiens* is much more close than in the case of *C. tipuliformis*, the leg-markings affording the main external distinction. The larva is undescribed; it was found by Dr. Lamborn in company with that of *C. fatigans*.

Distribution.—So far as our present knowledge goes, this species is confined to the eastern part of the Palaearctic and Oriental regions, into which *C. tipuliformis* apparently does not extend. Hong Kong (*Macfarlane*); Sikkim (*Wyville-Thompson*); Vladivostok and River Amur (*Wuorentaus*: Helsingfors Museum); Shanghai *Lamborn*).

16. **Culex laticinctus,** Edw.

Culex laticinctus, Edwards, J. Proc. Asiatic Soc. Bengal, ix, p. 49 (1913).

This species differs markedly from *C. pipiens*, the one to which it approaches most nearly in size and appearance, in the pure white abdominal bands, which are as broad as or broader than the dark bands which alternate with them. The male palpi are no longer than the proboscis, and are less hairy than those of *C. pipiens*. The prothoracic lobes often show a number of flat scales on the lower part. The hypopygium is not unlike that of *C. orientalis*, especially in the form and hairiness of the side-piece, but the appendages of the lobe and the structure of the mesosome are different.

The rather remarkable larva has been described and figured by Storey as "Culex sp. no. 2258."

Distribution.—Throughout the Mediterranean region; Canary Islands (Orotava, *Graham-Smith*); southern Spain (Aguilas, *G. Boag*); southern France, and as far north as Paris (*Séguy*); Tunis (Tamerza, *Langeron*; Djerba, *in coll. Bezzi*); Anatolia (Budrum, Mus. Civ. Genova); Cilicia, Syria and Palestine (*Barraud*; Mt. Carmel, *Austen*; Jerusalem, *Goldberg*); Egypt (*Storey*); Arabia (Muscat, *Gill*).

17. **Culex perexiguus,** Theobald (figs. 17, 18).

Culex perexiguus, Theobald, Mon. Cul. iii, p. 199 (1903).

The very small size of this species, together with the narrow white (not ochreous-white) abdominal bands, and the pale stripe on the outer side of the hind tibia (not always very clearly marked, and in the male sometimes indistinguishable), will serve to separate it from other members of the group with dark tarsi and basally banded abdominal tergites. Apart from this, and the aedoeagal structure, *C. perexiguus* may be known by the colour of the mesonotal scales, dark brown mixed with brassy ochreous.

I cannot detect any difference whatever between the adults of *C. perexiguus* and the West African form of *C. univittatus*, either in external characters or male hypopygial structure. The larvae, however, seem to be utterly different. Some confusion has existed regarding the larvae of *C. univittatus*, but Dr. Ingram assures me that the larva described and figured by him and Dr. Macfie (Bull. Ent. Res. x, p. 68) was identified by the isolation method, and he is sure that no error occurred. The figure indicates a larva similar in many respects to that of *C. quasigelidus*, but with several remarkable features, such as the possession of only a single pair of minute siphonal tufts and an incomplete ring on the anal segment.

Larvae of *C. perexiguus* sent from Palestine by Capt. Barraud differ in practically every detail from the larva described by Ingram and Macfie, almost the only point

of resemblance being in the length of the siphon. The accompanying figures have been prepared from isolated skins sent by Capt. Barraud, the adults issuing from which I have examined. The following is Capt. Barraud's description :—

"Antenna light in colour except towards base and tip. Shaft clothed with spicules. Antennal tuft of about 24 subplumose hairs arising at about three-quarters from the base. Mid frontal hair tufts of subplumose hairs ; ante-antennal tuft of 8 hairs ; outer median tuft of 2, inner median of 3. Small lateral tuft above eye of about 4 very small hairs. Mental plate with 7 teeth on either side of the central one, the outermost tooth some distance below the others.

"Siphon about seven times as long as the width at base. Pecten of from 11–14 teeth; teeth slightly curved, with three secondary spines on one side ; last few teeth *slightly*

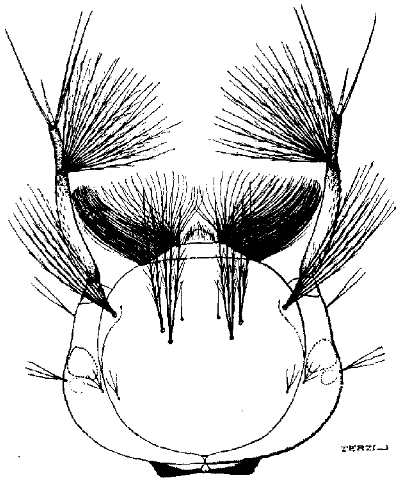


Fig. 17. *Culex perexiguus*, Theo., head of larva.

more detached than the remainder. Hair tufts on siphon represented by about four pairs of very short and fine hairs (towards tip usually single). Tufts on eighth segment of from 4 to 6 subplumose hairs. Comb of small teeth in triangular patch. Anal gills about the length of the anal segment, the dorsal pair rather longer than the ventral. Two or three hairs in the tuft on the dorsal edge of the anal segment. Brush well developed, about 12 tufts each with about 6 hairs."

Since it is impossible to consider two such different larvae as belonging to the same species, there is no alternative but to revive Theobald's name *perexiguus* for the Mediterranean form.

Distribution.—Palestine (*Cropper, Barraud*). Since it is impossible to separate the adults, the further distribution of *C. perexiguus* as distinguished from *C. univittatus* cannot be given, but it seems reasonable to assume that the form is the same throughout the Mediterranean region. From an examination of adults and from Storey's remarks on the larva it is obvious that this is the species he has recorded

from Egypt as *C. decens*; the larva of the African *C. decens* is indeed very similar, though the hypopygium differs. It is perhaps also the species recorded from Algeria by the Sergents as *C. fatigans*, since they state that the siphon is longer than that of *C. pipiens*. Adults, probably of *C. perexiguus*, have been received from southern Spain (*Fowler*), Muscat (*Gill*) and Amritsar, Punjab (*Barraud*).

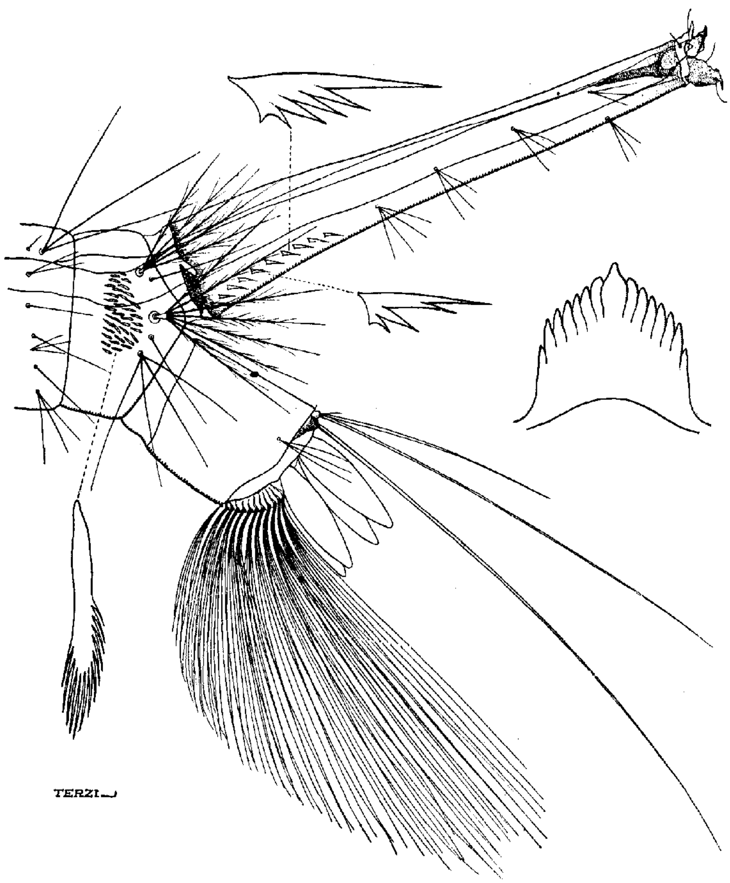


Fig. 18. *Culex perexiguus*, Theo., end of abdomen of larva; comb and pecten teeth and mentum more highly magnified.

18. **Culex laurenti**, Newst.

Culex laurenti, Newstead, Ann. Trop. Med. i, p. 24 (1907); Edwards, Bull. Ent. Res. v, p. 70 (1914).

The female of this species is almost impossible to distinguish from the unbanded variety of *C. pipiens*. The male differs from both *C. pipiens* and *C. perexiguus* in having no pale line beneath the last two joints of the palpi. I have figured the

hypopygium in the paper quoted. According to Storey the larvae are indistinguishable from those of *C. perexiguus.*

Distribution.—An Ethiopian species, known from Madagascar, Zanzibar, and the Congo, which has also been recorded from Egypt by Storey as *C. invidiosus.* Also found in Egypt by Austen (Kantara, Suez Canal). Perhaps occurs in Palestine (Acre and Jerisheh, *Austen ;* females only).

19. **Culex fatigans,** Wied.

Culex fatigans, Wiedemann, Aussereurop. zweifl. Ins. p. 10 (1828).
Culex quinquefasciatus (? Say), Howard, Dyar and Knab, Monogr. iii, p. 345 (1915).

This species may be distinguished from *C. pipiens* by the combination of some or all of the following characters :—Mesonotal scales somewhat coarser, with a dull brownish-ochreous instead of a dark brown or reddish-brown tinge (but Japanese and American specimens are often as red-tinged as *C. pipiens*). Upper fork-cell shorter in both sexes, that of the female being less instead of more than three times as long as its stem. Male palpi somewhat shorter and less hairy. Pale abdominal bands of the female rather more rounded. The only absolutely reliable distinction between the adults is, however, in the structure of the aedoeagus (see figures in Bull. Ent. Res. iv, pp. 54, 55). The larvae are rather more easily separated than the adults by the characters mentioned in the key.

Distribution.—This species, almost universal in the tropics, has a very limited area of occurrence within the Palaearctic region. I have only seen it from Lower Mesopotamia (*Barraud*), Seistan, eastern Persia (*Annandale*), and Japan (Kobe and Nagasaki, *Lamborn*). It has been recorded by various observers from southern Europe and North Africa, but I consider it highly probable that all such records refer to other species.

20. **Culex pipiens,** L.

Culex pipiens, Linnaeus, Syst. Nat. Ed. x, p. 602 (1758).
(?) *Culex fasciatus,* Müller, Fauna Insectorum Fridrichsdalina, p. 87 (1764).
(?) *Culex molestus,* Forskål, Descriptiones Animalium, p. 85 (1775).
(?) *Culex luteus,* Meigen, Klass. i, p. 6 (1804).
(?) *Culex domesticus,* Germar, Reise nach Dalmatien, p. 290 (1817).
Culex rufus, Meigen, Syst. Beschr. i, p. 7 (1818).
(?) *Culex bicolor,* Meigen, Syst. Beschr. i, p. 9 (1818).
(?) *Culex pallipes,* Waltl, Reise Tyrol etc. ii, p. 110 (1835).
Culex pallipes, Macquart, Dipt. Exot. i, i, p. 33 (1838).
(?) *Culex pallipes,* Meigen, Syst. Beschr. vii, p. 1 (1838).
(?) *Culex meridionalis,* Leach, Zool. Journ. ii, p. 292 (1825).
Culex marginalis, Stephens, Zool. Journ. i, p. 455 (1825).
(?) *Culex thoracicus,* Robineau-Desvoidy, Mém. Soc. d'Hist. Nat. Paris, iii, p. 409 (1827).
(?) *Culex calcitrans,* Robineau-Desvoidy, *loc. cit.*
(?) *Culex rufinus,* Bigot, Expl. Scient. Tunisie Dipt. p. 7 (1888).
Culex agilis, Bigot, Ann. Soc. Ent. France (6) ix, Bull. cxii (1889).
Culex phytophagus, Ficalbi, Bull. Soc. Ent. Ital. xxi, p. 126 (1890), and xxviii, p. 286 (1896).
Culex haematophagus, Ficalbi, Bull. Soc. Ent. Ital. xxv, p. 143 (1893).
Culex pallens, Coquillett, Proc. U.S. Nat. Mus. xxi, p. 303 (1898).
Culex melanorhinus, Giles, Gnats, p. 342 (1900).
Culex longifurcatus, Becker, Mitt. Zool. Mus. Berlin, ii, p. 68 (1904).

Culex nigritulus, Theobald, Mon. Cul. i, p. 140 (1901) (*nec* Zetterstedt).
Culex varioannulatus, Theobald, Mon. Cul. iii, p. 198 (1903).
Culex azoriensis, Theobald, Mon. Cul. iii, p. 210 (1903).
Culex quasimodestus, Theobald, Ann. Mus. Nat. Hung. iii, p. 88 (1905).
Culex osakensis, Theobald, Mon. Cul. iv, p. 439 (1907).
Culex pipiens var. *doliorum*, Edwards, Entom. xlv, p. 263 (1912).
(??) *Culex nigritulus*, Wesenberg-Lund, Danske Vid. Selsk. Skr. Nat. Math. Afd. (8) vii, p. 131 (1921).

The distinctions in external characters between the adults of *C. pipiens* and *C. fatigans* have been enumerated above. I have found them reliable in sorting out Mesopotamian specimens, where the two species occur together and *C. pipiens* is fairly constant; but in the southern and eastern Mediterranean region *C. pipiens* is subject to so much variation that the hypopygial differences would have to be relied on; the structure of this organ in *C. pipiens* is fairly constant, the slight variation that does occur showing usually little or no approach to *C. fatigans*.

The examination of a number of mounts of hypopygia of Japanese specimens, however, seems to show that the Japanese race of *C. pipiens* differs constantly from the European, having the second division of the mesosome much broader than usual and the third division not quite so stout, thus being to some extent intermediate between *C. pipiens* and *C. fatigans*. Theobald's type male of *Culex osakensis*, which in 1912 I took to be *C. fatigans*, belongs to this form, but Coquillet's name *pallens* is no doubt also applicable, and should be used to designate the variety. It would seem from their figures that Dyar and Knab's *Culex comitatus*, described from California, belongs to this var. *pallens* rather than to typical *C. pipiens*, and it is quite likely to have been introduced into California from Japan. In both *C. pipiens* and *C. fatigans* a minute basal arm to the tenth sternites may be present or absent.

A variety of frequent occurrence in the Mediterranean region has the pale bands of the abdomen reduced to lateral spots, either in the female only, or in both sexes. There are also two other varieties worthy of special mention. In North Africa many specimens occur with the mesonotal scales more or less ochreous, and in some the dark parts of the abdomen also tend to this colour, so that it is tempting to assume that we have here an incipient modification in colour to suit desert conditions. I have examined the hypopygium of one specimen so coloured, and have no doubt as to its identity. Theobald has described this variety as *C. quasimodesta*, but it is doubtful if it is at present more than a sporadic variation. The second variation is in the length of the upper fork-cell of the female. Over the greater part of the range of the species this is fairly constant, but in the Levant and Asia Minor many specimens are found in which the cell is shorter than usual, and little, if any, longer than that of *C. fatigans*. It seems rather significant that this very region is on the borders of the range of *C. fatigans*; the possibility of interbreeding may be indicated, but, against this, it should be noted that such intermediate specimens have not been found in Mesopotamia, where the two species are known to occur together.

I am indebted to Capt. Barraud for calling my attention to the existence of what seems to be a definite larval variety of *C. pipiens* in Palestine and Syria. In this form the average number of pecten-teeth is 12, and there seems to be little variation from this; of 39 specimens critically examined by Capt. Barraud, no fewer than 24 had either 12 or 13 pecten teeth, the number in the remaining specimens varying from 9 to 17. Further distinctions of this Levantine race are the smaller average size, the lighter-coloured antennae, and the shorter average length of the siphon (index about 4·5).

Capt. Barraud found that in Mesopotamian specimens the average number of pecten teeth was greater and the range of variation more. Out of 27 specimens examined the average number of teeth was 15·7; only 10 specimens had either 15

or 16 teeth, the number in the others ranging from 12 to 20. These specimens also had dark antennae, and the average size was larger and the average length of the siphon rather greater (index about 5). I find that specimens from Britain and Macedonia, though rather variable, agree in the main with this Mesopotamian type, which may therefore be taken as the common European form.

I have not been able to detect any constant difference between Palestine adults and those of other countries. Both the banded and unbanded forms occur there, and, as mentioned above, some (but by no means all) of the females have the upper fork-cell shorter than usual. It may be noted that in its several peculiarities the Palestine larva of *C. pipiens* approximates to that of *C. fatigans*.

It is possible, as long ago suggested by Ficalbi, that there are two races of this species, differing little, if at all, externally, but one being more addicted to sucking human blood than the other. In England *C. pipiens* will certainly attack man at times, but can seldom be regarded as troublesome; I have never myself experienced its bite, nor found a blood-gorged female in a bedroom. In south Europe, however, the reports of various observers lead one to suppose that it is more regularly addicted to feeding on human blood. Further experience may possibly show that the Palestinian type of larva described above is widely distributed in the Mediterranean region and represents the more troublesome race. If this should be proved to be the case the varietal name *molestus*, Forskål, might be applied to this form.

Wesenberg-Lund describes as *C. nigritulus*, Theo., a *Culex* larva which seems to differ in many respects from *C. pipiens*: *e.g.*, in the shape of the mentum and of the pecten-teeth and comb-scales and in the longer siphon. As I have not seen the adults reared from these larvae, I will only remark that the larvae of my *C. pipiens* var. *doliorum* (which I considered identical with Theobald's *C. nigritulus*, and which I do not now consider even varietally distinct from *C. pipiens*) conform fairly well to Wesenberg-Lund's description of *C. pipiens*.

Synonymy.—It is impossible to say what species were actually intended by most of the old descriptions, but I think it probable that the names *C. bicolor*, Mg., *C. pallipes*, Mg., *C. thoracicus*, R.-D., *C. calcitrans*, R.-D., and perhaps also *C. luteus*, Mg., were based on more or less rubbed specimens of this species. From the habits indicated by Forskål and Germar for *C. molestus* and *C. domesticus* it seems probable that this species was intended, *C. fatigans* being excluded owing to its now apparently established absence from Europe and Egypt. The description of *C. pallipes*, Waltl, was evidently supplied by Meigen, and amplified by him in 1838. The British Museum possesses a copy of Meigen's Abbildung eur. zweifl. Ins., hand-coloured by the author, in which the figure of *C. rufus* evidently represents *C. pipiens*, though the venation is shown in a conventional manner.* In his diagnosis of *C. meridionalis*, Leach says "abdomine segmentis omnibus postice griseo marginatis," but as he makes a similar statement regarding his *C. nicaensis* and *C. musicus*, it seems probable that by "postice" he meant "basally." Ficalbi's description of *C. phytophagus*, especially as regards the male palpi and abdominal bands, shows that he had *C. pipiens*, not *C. laticinctus* or *C. univittatus*, before him. I have examined the types of *C. marginalis*, *C. agilis*, *C. varioannulatus*, and *C. azoriensis*, and find them to be *C. pipiens*. Dr. Dyar informs me that he has examined Coquillett's type of *C. pallens*, and that it is *C. pipiens*. The species has frequently been referred to as *C. ciliaris*, L., but I think probably incorrectly.

Distribution.—Throughout the Palaearctic region; also in parts of North and South America, East and South Africa, and Madagascar; no doubt spread by commerce.

---

* It may also be remarked here that the figures in this work of *C. vexans* and *C. annulipes* agree with the interpretation of these names adopted in this paper. Some of the other figures are less decisive.

Bibliography.

The following list includes only the more important of the works dealing with Palaearctic CULICIDAE from the entomological point of view; purely economic works, as well as obsolete systematic papers, are not included. A fairly full bibliography, up to the end of 1919, is given by Martini in "Ueber Stechmücken."

BARRAUD, P. J. Notes on some Culicidae collected in Lower Mesopotamia.—Bull. Ent. Res. x, 1920, pp. 323–325.

——. Mosquitos collected in Palestine and adjacent territories.—Bull. Ent. Res. xi, 1921, pp. 387–395.

BLACKLOCK, B. and CARTER, H. F. Observations on *Anopheles* (*Coelodiazesis*) *plumbeus*, Stephens, with special reference to its breeding-places, occurrence in the Liverpool district, and possible connection with the spread of malaria.—Ann. Trop. Med. xiii, 1920, pp. 413–446, pls. x–xii.

BROLEMANN, H. W. Sur quelques *Culex* de Pyrénées et description d'une éspèce nouvelle.—Ann. Soc. Ent. France, lxxxvii, 1918, pp. 425–440; lxxxviii, 1919, pp. 65–103; lxxxix, 1920, pp. 51–73. (Includes good figures of the male hypopygia of most of the species found in France.)

CARTER, H. F. Descriptions of the male genital armatures of the British Anopheline mosquitoes.—Ann. Trop. Med. xiii, 1920, pp. 453–457 figs.

CHRISTOPHERS, S. R. The male genitalia of Anopheles.—Ind. J. Med. Res. iii, 1915, pp. 371–394, pls. xx–xxv.

——. Notes on some Anophelines from Arabia and Mesopotamia.—Ind. J. Med. Res. iii, 1915, pp. 180–200, pl. xvi.

——. Recent observations on the Anopheles of the Middle East.—Ind. J. Med. Res. vii, 1920, pp. 710–716, 3 maps.

——— and SHORTT, H. E. Malaria in Mesopotamia.—Ind. J. Med. Res. viii, 1921, pp. 508–552.

ECKSTEIN, F. Zur Systematik der einheimischen Stechmücken—Centralbl. f. Bakt., Parasit. u. Inf.-Krankh., 1 Abt., lxxxii, 1918, pp. 57–68, figs. (females); lxxxiii, 1919, pp. 281–294, figs. (larvae); lxxxiv, 1920, pp. 223–240, figs. (males).

——. Die einheimischen Stechmücken. Eine Schilderung ihrer Lebensweise und anleitung zu ihrer Bestimmung, Mit 17 Abbild.—Wiss. Mitglied des Forschungsinst. f. angew. Zool. Berlin, 1920, 58 pp. (Largely a reprint of above series of papers, with some biological and other details added.)

FICALBI, E. Revisione delle specie europee della fam. delle Zanzare.—Bull. Soc. Ent. Ital. xxiv, 1892, pp. 257–284; xxv, 1893, pp. 48–61, 136–144; xxvi, 1894, pp. 66–75, 315–320; xxvii, 1895, pp. 29–38; xxviii, 1896, pp. 108–313, pls. i–v. (The earlier sections include quotations of the original descriptions of all European species then known.)

——. Venti specie di Zanzare (Culicidae) Italiane.—Bull. Soc. Ent. Ital. xxxi, 1899, pp. 46–234, figs.

FOLEY, H. Etude morphologique de *Pyretophorus chaudoyei* Théob., aux differents stades de son evolution.—Campagne antipaludique de 1911, Alger, 1912, pp. 49–50, pls. iii–v.

GALLI-VALERIO, B. Sechzehn Jahre Untersuchungen über Kuliziden und Malaria.—Arch. Schiffs. Hyg. xxii, 1918, pp. 154–158. (Briefly summarises the author's work, with bibliography of his 45 short papers.)

GOETGHEBUER, M. Culicides et Corethrides de Belgique.—Ann. Soc. Ent. Belg. 1910, pp. 81–87, 410–412.

JOYEUX, C. Note sur les Culicides de Macédoine.—Bull. Soc. Path. Exot. II, 1918, pp. 530–547.

LANG, W. D. Handbook of British Mosquitoes.—London, British Museum (Natural History), 1920.

LANGERON, M. Remarques sur les larves du *Culex geniculatus* et sur les larves de Culicinés pourvues d'un long siphon.—Bull. Soc. Path. Exot. ix, 1916, pp. 438–442, figs.

——. Remarques sur l'évolution larvaire de *Theobaldia annulata* (Schrank, 1776).—Bull. Soc. Path. Exot. ix, 1916, pp. 703–708, figs.

——. Morphologie et biologie de la larve de *Theobaldia spathipalpis*, Rondani, 1872.—Bull. Soc. Path. Exot. xi, 1918, pp. 98–103, figs.

——. La larve d'*Anopheles chaudoyei* (Theobald, 1903).—Bull. Soc. Path. Exot. xi, 1918, pp. 291–297, figs.

LEON, N. Studii asupra Culicidelor din România.—Bucuresti, 1910, Directiunea Generale a serviciului sanitar. Pp. 274, pls. xv, figs. 111.

——. Contributions à l'étude des Culicides de Roumanie.—Centralbl. f. Bakt. liii, 1910, pp. 499–505.

MARTINI, E. Über Stechmücken, besonders deren europäische Arten und ihre Bekämpfung.—Archiv f. Schiffs- und Tropenhyg. Band 24, Beiheft 1, 1920, pp. 1–267, pls. i–iv, 117 text figs.

——. Die biologische Malariabekämpfung in Mazedonien.—Zeitschr. f. Angew. Ent. vii, 1921, pp. 225–286.

DE MEIJERE, J. C. H. Zur Kenntnis niederländischer Culiciden.—Tijd. v. Ent. liv, 1911, pp. 137–157, pls. viii–x.

NUTTALL, G. F. H. and SHIPLEY, A. E. The structure and biology of *Anopheles*.—Journ. Hyg. I, 1901, pp. 45–77, 269–276, 451–482, pls. i, ii, viii–x; II, 1902, pp. 58–84, 166–215, pls. vi–viii.

SCHNEIDER, P. Beitrag zur Kenntnis der Culiciden in der Umgebung von Bonn.—Verh. Nat. Ver. Preuss. Rheinl. u. Westf. lxx, 1914, pp. 1–54, 2 pls.

SÉGUY, E. Les moustiques de France.—Bull. Mus. d'Hist. Nat. Paris, 1920, pp. 51–58, 141–149, 223–230, 322–329, 407–414, 512–519.

——. Remarques sur quelques larves de moustiques.—Bull. Soc. Ent. Fr. 1920, pp. 309–311.

——. Note sur l'armure génitale du *Culex jugorum* Villen.—Bull. Soc. Ent. Fr. 1921, pp. 39–40.

SERGENT, Ed. et Et. Observations sur les moustiques des environs d'Alger.—Ann. Inst. Pasteur, xvii, 1903, p. 60.

——. Observations sur les Anopheles d'Algerie.—Ann. Inst. Pasteur, xix, 1905, p. 144, and xx, 1906, p. 393.

STOREY, G. Keys for the determination of Egyptian Mosquitoes and their larvae.—Bull. Soc. Ent. Egypte, Cairo, 1918 (1919), pp. 84–106, 2 pls.

VASSILIEV, J. B. *Cellia pulcherrima*, Theo., und einige neue Angaben über Erscheinen und Überwintern von *Anopheles bifurcatus*, L., in Turkestan. (See Rev. App. Ent. i, p. 193.)

WATERSTON, J. On the mosquitos of Macedonia.—Bull. Ent. Res. ix, 1918, pp. 1–12.

WESENBERG-LUND, C. Anatomical description of the larva of *Mansonia richardii* (Ficalbi) found in Danish freshwaters.—Vidensk. Medd. Dansk. naturhist. Forn. lxix, 1918, pp. 277–328, figs.

——. Contributions to the biology of the Danish Culicidae.—D. Kgl. Danske Vidensk. Selsk. Skrifter, Nat. Math. Afd., 8 Raekke, vii, 1921, pp. 1–210, pls. i–xxi.

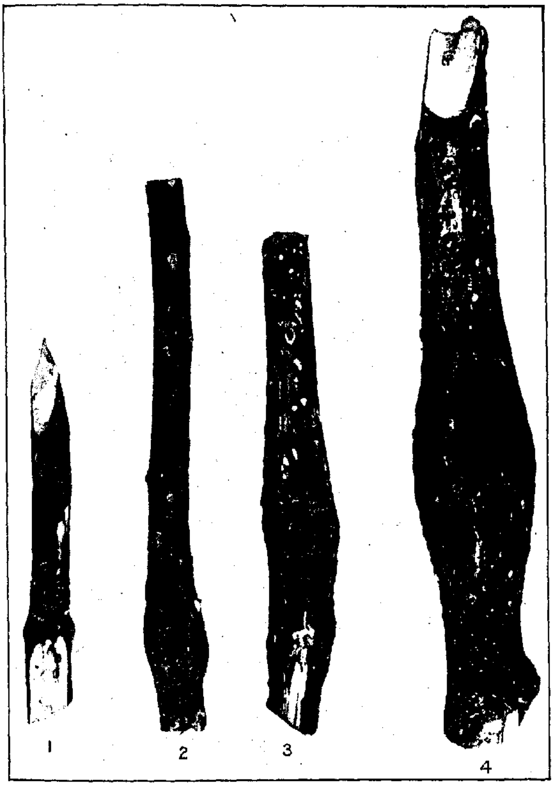
Index of Specific and Varietal Names applied to Palaearctic Mosquitos.

(Synonyms and unrecognisable names in *italics*.)

AGRILUS FOVEICOLLIS, MARS., AS A CAUSE OF THE DECAY OF THE CULTURE OF ROSES IN BULGARIA.

By Prof. S. A. Mokrzecki.
Experimental Agricultural Institute, Sofia.

During the months of May and June 1921 I investigated the cause of the serious losses that had occurred among the rose-trees (especially *Rosa damascena*, Mill.) which are extensively grown in Bulgaria for making attar of roses. The conclusion arrived at is that the cause of the general decline in rose culture is inadequate



Galls on stems of *Rosa damascena*, caused by the larvae of *Agrilus foveicollis*, Mars.—1, One-year-old shoot; the bark is cut off and the burrows of the three to four days' old larva may be seen; no swelling is formed yet. 2, Two-year-old shoot, with a swelling near its base; the top of the shoot was beginning to dry up. 3, Two-year-old shoot, with the swelling cut open; several annular passages are clearly visible. 4, Three-year-old shoot, on which the swelling is very distinct; by this time the majority of the small branches had already faded. All photographs taken from nature and slightly enlarged.

nourishment of the plants, owing to an insufficient amount of humus and nitrogen in the soil, aggravated by the entire neglect of manuring by the growers. But the immediate cause of the death of thousands of rose-bushes has proved to be certain galls that are to be found on the stems, reaching 2–3 cm. in length and sometimes twice as thick as the normal stem.

When the gall is cut open, dark-coloured burrows may be seen circling the stem just under the bark, the number varying from three to fourteen. Up till now, however, no insects have ever been found in these galls, and previous investigators attributed them to *Agrilus viridis*, L.* Injuries of this kind have been also recorded on roses in Italy† and France,‡ and Houard§ attributes them to the activity of larvae of some Microlepidopteron.

My investigations have led me to the conclusion that the galls are caused by the larvae of *Agrilus foveicollis*, Mars.,‖ a species described from Siberia and never recorded previously from any locality in Europe.

The life-cycle of this new and very destructive pest of roses is not quite clear, but the following points have been actually observed by myself. The beetles appear in the middle of May and live on the leaves of roses, nibbling their margins. The female, after copulation, lays her eggs, up to 30 in number, each separately, under the bark of one-year-old shoots. Each egg is laid in a scarcely perceptible oblong hole, made by the ovipositor; it is about 0·3–0·4 mm. long, white, with the surface covered with a network of fine furrows. The eggs hatch after 5–7 days, and even during the first 2–3 days of its life the larva may make as many as three annular burrows around the shoot, under the bark, filled with black excrement. No swelling, however, is formed during the first summer (fig. 1). In the second year the swelling is noticeable and increases gradually (figs. 2 and 3), while the infested shoot begins to dry up. In the third year the whole stem gradually dies (fig. 4).

The life of the larva lasts apparently about one year, and that is why larvae are not to be found in the galls which are already well formed. There may be several galls on the same stem.

* Dr. Nikoloff, M. Stefanoff and N. Pouchkareff: "The Culture of Roses in Bulgaria," Revue d'Inst. des Recherches agronomiques en Bulgarie, i, nos. 5 & 6, 1921, pp. 11–14 (in Bulgarian). There is a figure of *A. viridis*, L., and its larva and cocoon, with descriptions taken from Richter von Binnenthal's book: "Die Rosenschädlinge aus dem Tierreiche," Stuttgart (1903), as well as original figures of the burrows as observed by the authors in Bulgaria.

† Del Guercio, "Intorno ad una deformazione del fusto della Rosa in Italia."—Nuove Relaz. Staz. Entom. Agr. Firenze, pp. 143–146, pl. ix, figs. 1–2.

‡ J. Beauderie, "Les Croussins du Rosier."—Hort. Nouv. Lyon, 1911.

§ "Les Zoocecidies des plantes d'Europe," i, p. 542.

‖ Coleopt. Hefte, v, 1869. I am much indebted for the identification of my specimens to the Imperial Bureau of Entomology and to its Director, Dr. G. A. K. Marshall.

NOTES ON A COLOUR TROPISM OF *ASTEROCHITON* (*ALEURODES*) *VAPORARORIUM*, WESTWOOD.

By Ll. Lloyd, D.Sc. (Leeds).

During 1919–20 an investigation into the habits of *Asterochiton* (*Aleurodes*) *vaporariorum*, Westw., was being carried out at the Lea Valley Experimental Station, Cheshunt, with a view to controlling its attacks on tomatoes under glass. The station exists for the study of scientific problems connected with the glasshouse industry, and as the staff is small, the work is necessarily confined to strictly economic lines. Points that appear in the course of the investigations cannot be followed to their ultimate conclusion in these earlier years of the station's existence if they seem to be of theoretical rather than of practical importance. The following notes relate to such a problem, which it has been decided to record, though in a very unfinished state.

A habit of this whitefly of settling upon clothing led to a short study of its colour reactions. All the experiments were carried out in a heated greenhouse in December and January. A wooden cage was used, 18 in. by 18 in. by 24 in. high, with the bottom six inches forming a wooden well, and above this four sides and a roof of muslin. An exactly similar wooden framework without the muslin was also employed, its sides and roof being open to the greenhouse.

Experiments with Transmitted Light.

Various weak solutions in water of substances conveniently to hand were made up. Clear white glass corked tubes one inch in diameter and three in length were filled with the solutions to a depth of one and a half inches, and the outsides of the tubes to the same depth were thinly smeared with a clear adhesive composed of resin and castor oil. The tubes were then hung by strings around the four sides of the frame so that they were equidistant from each other and about fifteen inches from the centre of the well. Cut infested foliage was placed in the floor of the well. During the tests the positions of the tubes were interchanged, the least attractive to the position of the most attractive, and so on, or the whole frame was revolved through 90°. The insects were removed by means of a needle and counted at intervals of from one hour to two days.

Experiment 5.

December 3rd; bright sun; exposure, seven hours of daylight. Twelve weak solutions were made up at random to give a wide range of colours; 452 flies were trapped, and their distribution is shown in diagram 1 by the continuous line. The following solutions were attractive in order of merit: light yellowish-green (picric acid+jodgrün), fluorescent (weak eosin), greenish-yellow (picric acid), orange (orange G.). The following gave negative results: water, bright red (fuchsin), blood red (Congo red), blue-green (methyl green), pale blue (methylene blue), indigo (nachtblau) and violet (gentian).

Experiment 6.

December 5th–6th; dull; exposure 16 hours' daylight. Solutions as above, with three others added; 266 flies were trapped, and their distribution is shown in diagram 1 by the broken line. The same solutions as in the last experiment, together with purple (potassium permanganate), proved negative. The eosin solution was only moderately attractive, and a strong solution of potassium bichromate rather

less so, but a weak solution of the same substance was the most attractive in the test, trapping nearly a quarter of the total flies caught.

It was evident from these and from other crude tests that the attractive solutions all had a predominating yellow colour, or were fluorescent. The next experiments were carried out in an endeavour to find an optimum attraction.

Experiment 9.

December 9th–15th ; little weak sunlight ; exposure 56 hours' daylight. Solutions of potassium bichromate (yellow fluorescent) of percentage strengths 5, 1, $\frac{1}{4}$, $\frac{1}{16}$, $\frac{1}{64}$, $\frac{1}{256}$, two tubes of each ; 1,771 flies were trapped, and their distribution is shown in diagram 2. The optimum strength for this solution was clearly from $\frac{1}{4}$ to $\frac{1}{16}$ per cent., from the nature of the curve between these two ; $\frac{1}{8}$ per cent. potassium bichromate was therefore used as a standard in the next experiment.

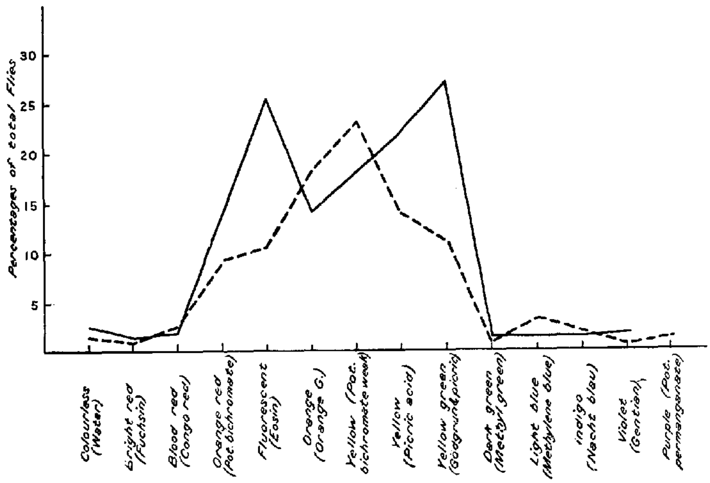


Diagram 1. (See Experiments 5 and 6.)

Experiment 10.

December 16th–20th ; little weak sunlight ; exposure 40 hours of daylight. Four solutions of orange G. of strengths $\frac{1}{4}$, $\frac{1}{16}$, $\frac{1}{128}$, and $\frac{1}{512}$ per cent., and four of eosin of strengths $\frac{1}{4}$, $\frac{1}{16}$, $\frac{1}{64}$, and $\frac{1}{256}$ per cent., one tube of each, were tested against four control tubes of $\frac{1}{8}$ per cent. potassium bichromate ; 983 flies were trapped, and had the distribution shown in diagram 3. The eosin solutions were relatively unattractive, but the nature of the curve shows that there was some attraction, the optimum strength being about $\frac{1}{128}$ per cent. It may be pointed out that the occasion when the attraction of this substance was powerful was when tested in bright sunlight, its other tests being all in dull weather with intermittent weak sun. The solutions of orange G. were less attractive than the control except the $\frac{1}{128}$ per cent. solution, which drew 60 per cent. more flies. In the course of the experiment three counts were made on the twelve tubes, and this tube trapped most flies in each case, except that it was bettered once by a control, 53 as against 42. An attempt was made to analyse the maximum point on the orange G. curve in the next experiment.

Experiment 12.

December 20th–23rd; little weak sunlight; 32 hours' daylight. Three strengths of orange G., $\frac{1}{64}$, $\frac{1}{128}$, $\frac{1}{256}$ per cent., four tubes of each; 849 flies were trapped as follows: $\frac{1}{64}$ per cent., 257 flies (30 per cent.); $\frac{1}{128}$ per cent., 274 flies (32 per cent.); $\frac{1}{256}$ per cent. 318 flies (37 per cent.). This is not a decisive result, although the figures appear to be graded, the differences being within the range of experimental error and rather erratic in the separate counts.

The solution which drew forth the greatest response was thus one of orange G., of a strength approximating to $\frac{1}{128}$ per cent.

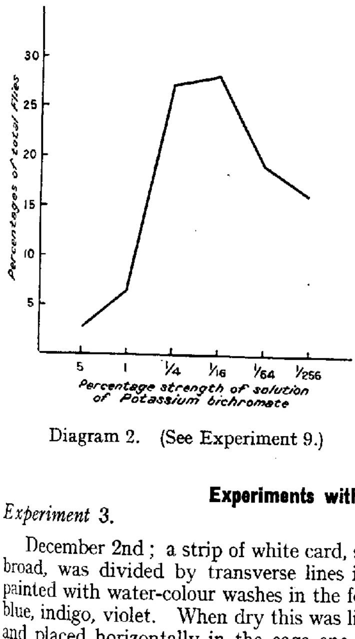


Diagram 2. (See Experiment 9.)

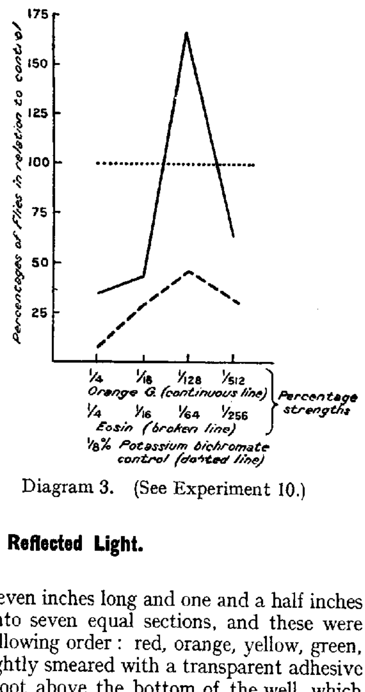


Diagram 3. (See Experiment 10.)

Experiments with Reflected Light.

Experiment 3.

December 2nd; a strip of white card, seven inches long and one and a half inches broad, was divided by transverse lines into seven equal sections, and these were painted with water-colour washes in the following order: red, orange, yellow, green, blue, indigo, violet. When dry this was lightly smeared with a transparent adhesive and placed horizontally in the cage one foot above the bottom of the well, which contained infested foliage. The flies left the foliage and flew to the top of the cage, and were then in a position to see the trap. The card was exposed for two hours, the sun being bright. At the end of the first hour the card was turned, to reverse the position of the colours. In all, 397 flies were trapped, and their distribution is shown in diagram 4. Orange, green and yellow proved attractive, the last-named trapping 51 per cent. of the total. The four remaining colours held only about 10 per cent. of the total catch.

Experiment 11.

December 19th–20th; a small tomato leaf one and a half inches long was taken, and six pieces of paper of the same size and shape were washed with water-colours as follows: red, orange, yellow, yellowish-green, blue and white. Each of these